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1992

EPA Superfund
Record of Decision:

MILAN ARMY AMMUNITION PLANT
EPA ID: TN0210020582
OU 01
MILAN, TN
09/30/1992

Text:
MILAN ARMY AMMUNITION PLANT (MAAP) O-LINE PONDS GROUNDWATER OPERABLE UNIT

Milan, Tennessee

INTERIM ACTION
RECORD OF DECISION

FINAL DOCUMENT

September 30, 1992

In accordance with Army, Regulation 200-2, this document is intended to comply with the National Environmental Policy Act (NEPA) of 1969.

DECLARATION FOR THE RECORD OF DECISION

SITE NAME AND LOCATION

O-Line Ponds Area, Milan Army Ammunition Plant (MAAP), Milan, Tennessee

STATEMENT OF BASIS AND PURPOSE

This decision document presents the selected remedial action for Operable Unit One (OU 1) at the O-Line Ponds Area, Milan Army Ammunition Plant, Milan, Tennessee. The selected remedial action was chosen in accordance with the requirements of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), and to the extent practicable, the National Oil and Hazardous Substances Pollution Contingency Plan (NCP, 40 CFR 300). This decision document explains the factual basis for selecting the remedy for OU 1 and the rationale for the final decision. The information supporting this remedial action decision is contained in the Administrative Record for this site.

The U.S. Environmental Protection Agency and the State of Tennessee concur with the selected remedy.

ASSESSMENT OF THE SITE

Actual or threatened releases of hazardous substances from the site, if not addressed by implementing the response actions selected in this Record of Decision (ROD), may present an imminent and substantial endangerment to public health, welfare, or the environment.

DESCRIPTION OF THE REMEDY

The goal of the overall cleanup activities at the site is to reduce the levels of contaminants to below health-based concentrations, such that noadverse health effects will result from current and future off-post or onpost use. Presently, more information is available concerning the nature and extent of groundwater contamination than is known about soil, surface water, and sediment contamination within the O-Line Ponds area. Because contaminated groundwater potentially poses an unacceptably high level of risk to human health and is better defined, this environmental medium has been separated from the others. This separation of environmental media into Operable Units (OU) allows the Army to begin groundwater cleanup prior to full assessment of the entire site.

The Operable Units are defined as follows: Operable Unit One (OU 1) addresses contaminated groundwater beneath and immediately downgradient from the former ponds which has been contaminated by past disposal practices at the ponds. Operable Unit Two (OU 2) addresses contaminated soils beneath and around the former ponds and surface water and sediment in the drainage ditch that flows along the east and north sides of the ponds, which may have become contaminated as a result of past disposal practices. Operable Unit 14 (OU 14) addresses the area downgradient (to the north and northwest) of OU 1 and OU 2, including Line K. This Record of Decision presents specific remedies that were considered for OU 1 only. Remediation methods for OU 2 and OU 14 will be selected as separate actions.

The major components selected for remediating OU 1 are as follows:

- Downgradient extraction of contaminated groundwater using extraction wells;

- On-site treatment of extracted groundwater using electrochemical precipitation to remove inorganic constituents; ultraviolet (UV)-oxidation to destroy the majority of the organic contaminants in the water; and granular activated carbon (GAC) to remove remaining organic compounds;

- Re-injection of treated groundwater upgradient of the former ponds;

- Monitoring well installation to determine extraction effectiveness; and

- Institutional controls will be used to prevent human exposure to the contaminated groundwater.

The principal threat at this site, groundwater contaminated with explosives, will be addressed by removing contaminated water from the aquifer and permanently treating the water with a combination of electrochemical precipitation to remove inorganics and UV-oxidation with GAC to remove organic contaminants from the water.

In pursuit of the overall site goal of reducing the levels of contaminants to health-based levels, UV-oxidation, an innovative technology, will be used to remove explosives compounds from extracted groundwater. This technology was selected because of uncertainties regarding the ability of more commonly -used technologies in reducing the concentrations of contaminants to the health-based levels. UV-oxidation has not previously been applied in full-scale systems to remove these contaminants; however, it has the potential to meet the stringent criteria.

The Army has elected to perform this phase of groundwater cleanup under an Interim Action Record of Decision (ROD), which allows for treatment system design, construction, operation (using the discharge limits listed herein, which for several explosives compounds are higher than health-based concentrations), and performance evaluation for a set period of time. At the end of the performance evaluation period, the treatment system capabilities and discharge levels will be reevaluated. If the health-based levels for any of the contaminants of concern have changed in the interim, these newvalues will be considered as the treatment goals. A final action remedy will be selected which satisfies all health based clean-up levels or provides technical data, consistent with CERCLA and the National Contingency Plan, which justifies alternative standards. The remedy selected in the interim action is consistent with planned future actions to the extent possible.

Because this interim remedial action requires that the further migration of contaminated groundwater within the O-Line Ponds area be stopped, and the concentrations of contaminants in groundwater be greatly reduced, it is consistent with any planned future actions.

STATUTORY DETERMINATIONS

This interim action is protective of human health and the environment, complies with Federal and State applicable or relevant and appropriate requirements for this limited scope action, and is cost effective. Although this interim action is not intended to fully address the statutory mandate for permanence and treatment to the maximum extent practicable, this interim action utilizes treatment and thus is in furtherance of that statutory mandate. Because this action does not constitute the final remedy for groundwater at the site, the statutory preference for remedies that employ treatment that reduces toxicity, mobility or volume as a principal element, although partially addressed in this remedy, will be addressed by the final response action for groundwater. Subsequent actions are planned to address fully the threats posed by the conditions in the groundwater at this site.

Because this remedy will result in hazardous substances remaining on site above health-based levels, a review will be conducted to ensure that the remedy continues to provide adequate protection of human health and the environment within five years after commencement of the remediation. Because this is an interim action ROD, review of this site and of this remedy will becontinuing as the Army continues to develop final remedial alternatives for groundwater at the site.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION IV

345 COURTLAND STREET, N.E.
ATLANTA, GEORGIA 30365

SEP 30 1992

4WD-FFB

CERTIFIED MAIL
RETURN RECEIPT REQUESTED

Mr. Lewis D. Walker
Deputy Assistant Secretary of the Army
(Environment, Safety and Occupational Health)
Attn: SAILE-ESOH
The Pentagon, Room 2E577
Washington, D.C. 20310-0110

Re: Interim Remedial Action Record of Decision
O-Line Ponds Groundwater Operable Unit
Milan Army Ammunition Plant
Milan, Tennessee

Dear Mr. Walker:

The United States Environmental Protection Agency (EPA) has reviewed the Department of the Army's Interim Remedial Action Record of Decision for the O-Line Ponds Groundwater Operable Unit at the Milan Army Ammunition Plant pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act of 1980, as amended by the Superfund Amendments and Reauthorization Act of 1986. EPA concurs in the findings and selected remedy presented in the Interim Record of Decision.

Sincerely yours,

Patrick M. Tobin
Deputy Regional Administrator

cc: Commissioner J. A. Luna, Tennessee Department of Environment and Conservation
Lt. Colonel Everette B. Crumpler III,
Commanding Officer, MAAP

STATE OF TENNESSEE
DEPARTMENT OF ENVIRONMENT AND CONSERVATION

Mr. Lewis D. Walker
Deputy Assistant Secretary of the Army
OSHA-I, LE
Office of the Assistant Secretary
Department of the Army
Washington, D.C. 20310-0103

Ref. 27-505 MAAP O-Line Ponds OPU-1 ROD

Dear Mr. Walker:

The Tennessee Department of Environment and Conservation has reviewed the final Interim Action Record of Decision submitted on September 30, 1992. This document has reference to the groundwater remediation operable unit at the O-Line Ponds Area at the Milan Army Ammunition Plant located in Milan, Tennessee. The Department concurs with the findings and the selected interim remedial action stated in this Record of Decision.

If you should have any questions regarding this matter please contact me at (615) 532-0228 or Mr. Ron Sells, TDEC Project Manager at (901) 4236600.

Sincerely,

Ken Bunting
Administrator, Bureau of Environment
Tn Dept of Environment & Conservation

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1.0 SITE NAME, LOCATION AND DESCRIPTION

Milan Army Ammunition Plant (MAAP) is located in western Tennessee, 5 miles east of Milan, Tennessee, and 28 miles north of Jackson, Tennessee (Figure 1 -1). MAAP is a government-owned, contractor-operated installation with Martin Marietta Ordnance Systems, Inc., as the operating contractor. The facility was constructed in 1941 to produce and store fuzes, boosters, and small- and large-caliber ammunition. At present, the facility comprises 22,436 acres.

MAAP lies within the coastal plain province of the Mississippi Embayment, west of the Western Valley of the Tennessee River and east of the Mississippi River Valley. The topography of MAAP and surrounding area is gently rolling to flat. It slopes regionally westward and contains numerous small streams, creeks, and drainage ditches. The elevation of the plant varies from a high of approximately 590 feet above mean sea level (ft-msl) on the south side to a low of approximately 320 ft-msl on the north boundary of the plant.

Numerous perennial and ephemeral surface water features occurwithin the installation and flow to the north-northwest. The entire facility, except for its extreme southern portion, drains via small creeks and ditches to the Rutherford Fork of the Obion River. The northern portions of MAAP contain several well-developed, ephemeral, natural drainage bodies that join the Rutherford Fork along the northern boundary of the installation. The two parent streams, the Forked Deer River and the Obion River, empty into the Mississippi River about 60 miles west of MAAP.

Groundwater is a primary source of potable and non-potable water in this area of Tennessee. At MAAP, the Memphis Sand of the Claiborne Group is the major aquifer, and is thick, laterally continuous, and highly transmissive. Groundwater flow in the MAAP area is generally to the west, in the direction of the regional dip of these sands, and also trends northerly because of the topographic influence. On a general scale, there are no abrupt hydrologic boundaries in the aquifer. The formation is recognized as sand with clay lenses and clay-rich zones.

The facility is located in a rural area, with agriculture being a primary land use. There are scattered residences to the north and east of the facility boundary. North of the facility, the nearest residences are located north of the Rutherford Fork, which probably acts as a shallow groundwater divide. These residences are downgradient from the O-Line Ponds area and are approximately 1.5 miles from the O-Line Ponds. On the east side of the facility, residences are located along the facility property line. These homeowners are not at risk from the contamination emanating from the O-Line Ponds because they are cross-gradient and upgradient from the O-Line Ponds. Within the facility, the Army performs regular monitoring of the potable water production wells to ensure that no contamination is present. Therefore, under current land use conditions, humans are not exposed to the contaminated groundwater in the OLine Ponds area. Future land use scenarios may present potential human health risks if the property is developed for residential use.

Of the thirteen process areas active by the end of World War II, only seven lines are in use today. As shown in Figure 1-2, the active process areas are distributed through the northern half of the facility. O-Line is located in the north central portion of MAAP. Immediately north of O-Line are the O-Line Ponds (now closed), which historically received wastewater from the operations conducted at O-Line. Contaminated groundwater that is addressed in this ROD emanates from the O-Line Ponds area, which is described in more detail in the next section.

2.0 SITE HISTORY AND ENFORCEMENT ACTIVITIES

The O-Line area (Figure 2-1) at MAAP was built as part of the initial plant construction activity in 1941, and has operated since 1942 as an ordnance demilitarization facility. From the start, the major function of the line has been to remove explosives from bombs and projectiles by injecting a high -pressure stream of hot water and steam into the steel shell of the munitions. The types of explosives handled in the facility include 2,4,6-trinitrotoluene (TNT) and RDX.

Wastewater contaminated with explosives was discharged from the OLine washout operations through a series of baffled concrete sumps where cooling caused significant amounts of explosives to precipitate out of the waste stream. Effluent from the sumps was initially discharged to an open ditch which ran through the O-Line area. In 1942, 11 individual surface impoundments were excavated to receive the O-Line effluent before discharge to the open ditch. The ponds (Figure 2-2) reportedly were excavated into native soil and the excavated material was used to form the pond dikes. The ponds were 3-5 feet deep, had a total capacity of 5.5 million gallons, and covered an area of about 280,000 square feet (USATHAMA, 1982a). The ponds were interconnected with a series of spillways, open ditches, and distribution boxes allowing several pond configurations to be used in series. Effluent from the last pond flowed through a bank of sawdust-filled tanks before discharge to Ditch B. The drainage ditch that received effluent from the final pond discharged to the Rutherford Fork of the Obion River which runs along the northern boundary of MAAP as shown in Figure 2-1.

In 1978, USATHAMA conducted an Installation Assessment of MAAP (USATHAMA, 1978), which consisted of a records search and interviews with employees. It was reported in this document that between 300 to 500 pounds of explosives could be washed out in an 8-hour shift, and that many types of explosive materials were handled in this area. At the time of the survey, all of the wastewater ponds were full and signs of overflow were obvious. The overflow entered the open ditch near O-Line.

Also in 1978, the U.S. Army Environmental Hygiene Agency's (USAEHA) water well sampling program (USAEHA, 1978) revealed that three of MAAP's 11 water supply wells were contaminated with explosive constituents. The affected wells were near a number of production areas, including O-Line.

MAAP facility personnel ceased using the O-Line Ponds since the ponds were determined to be one of the most likely sources of groundwater contamination. As a result, the O-Line operation was placed in a standby status in December 1978, and effluent has not been discharged to the ponds since that time. The impounded effluent remained in the ponds until 1981, when the supernatant was pumped out and treated in a newly constructed pink water treatment facility (PWTF), consisting primarily of carbon adsorption units and fabric filtration units. The effluent from the PWTF was discharged to the open ditch under the facility's NPDES permit. A PVC liner was placed on top of the pond sediments in 1981 and the liner was filled with fresh water to stabilize it.

MAAP subsequently prepared and submitted a closure plan for the pond site (USATHAMA, 1982b). The closure plan was approved by the Tennessee Department of Health and the Environment (TDHE) and implemented in 1984. The closure plan called for the construction of a multilayered cover system for the ponds. The ponds were filled with clean inorganic fill, and two clay layers were placed on top and compacted. A gravel drainage layer was placed between the clay layers. Topsoil was placed on top of the upper clay layer and a vegetative cover was then established.

The rationale for taking the ponds out of service and placing a liner on top of the contaminated soil was to decrease hydraulic loading on the source. The cap was designed to further minimize hydraulic loading on the contamination source by providing a multilayered cover system.

However, in May 1984, because of the level of contamination in the groundwater, the facility was proposed for listing on the National Priorities List (NPL). The NPL is EPA's list of hazardous waste sites that present the greatest potential threat to human health and the environment if remediation does not occur. Final listing on the NPL took place in August, 1987.

In 1990-1991, the U.S. Army Toxic and Hazardous Materials Agency (USATHAMA) conducted a Remedial Investigation (RI) at MAAP (USATHAMA, 1991). The RI was conducted to identify the type, concentration, and extent of contamination. Some of the results of the RI are as follows:

- The levels of explosives in groundwater samples collected near the ponds are very high (more than 10,000 times higher than EPA's health advisory levels). The concentrations of explosives in groundwater decrease as the distance from the O-Line Ponds increases. Available data indicate that the area of groundwater contamination associated with the ponds themselves is approximately 2,500 feet in length and possibly as much as 1,500 feet wide.

- The vertical extent of the groundwater contamination appears to extend from the water table to a maximum depth of 170 feet below the ground surface.

- It is likely that other sources of contamination exist downgradient of the ponds which have contributed to the total area of groundwater contamination. These areas are being addressed in additional studies.

- The contaminants of concern include explosives such as 2,4,6-trinitrotoluene (TNT), 2,4-dinitrotoluene and 2,6dinitrotoluene (DNT), RDX, HMX, nitrobenzene, 1,3,5-trinitrobenzene (TNB), and 1,3-dinitrobenzene (DNB).

In order to respond as rapidly as possible to the potential threat posed by contaminated groundwater in the vicinity of the O-Line Ponds, the Army has elected to separate the O-Line Ponds area from the remainder of the facility and to address remediation of this unit while further investigation of other units continues. In 1991-1992, a Focused Feasibility Study (FFS) of the O-Line Ponds area groundwater (OU 1) was conducted (USATHAMA, 1992a). The purpose of the FFS was to identify remedial technologies that are capable, singly or in combination, of mitigating the risks posed by the Operable Unit. Because several of the most promising technologies identified in the FFS have not been widely deployed, limited data are available to fully assess their potential effectiveness for the Operable Unit-specific conditions and contaminants. To fill this data gap, treatability studies were performed in 1992 to further evaluate the effectiveness, implementability, and cost of the most promising technologies.

Based on the information gathered and presented in the FFS report (and on the results of the treatability studies), the Army selected a preferred remedy for the O-Line Ponds area groundwater. The rationale behind the remedy was presented to the public in a Proposed Plan (USATHAMA, 1992b).

3.0 HIGHLIGHTS OF COMMUNITY PARTICIPATION

The RI report for MAAP was released to the public in December 1991 and presented at a public meeting held during the same month. The FFS report and Proposed Plan were released to the public in July 1992. All of these documents are available in both the Administrative Record and the information repository maintained at the Army Chief Engineer's Office at MAAP and the Mildred G. Fields Library, Milan, TN. The notice of availability of these documents was published in The Mirror Exchange on June 24, 1992 and The Jackson Sun on June 27, 1992.

A 45-day public comment period was held from July 1, 1992 through August 15, 1992. In addition, a public meeting was held on July 16, 1992. At this meeting, representatives from MAAP, EPA and TDEC answered questions about problems at the site and the remedial alternatives under consideration. Comments and responses from the July 16, 1992 Public Meeting have been captured in the meeting transcription, which is included in the Responsiveness Summary (Appendix A). No written comments were received during the comment period.

This decision document presents the selected remedial action for the O-Line Ponds Area, Milan Army Ammunition Plant, Milan, TN, chosen in accordance with CERCLA, as amended by SARA, and, to the extent practicable, the National Contingency Plan. In addition, this decision incorporates the findings of treatability studies conducted to determine the effectiveness of the treatment technologies selected as a result of the FFS. The decision for this site is based on the Administrative Record.

4.0 SCOPE AND ROLE OF OPERABLE UNIT OR RESPONSE ACTION

Past disposal practices at the O-Line Ponds contaminated soil and groundwater near the former ponds. The goal of the overall cleanup activities at MAAP is to reduce the levels of contaminants to below health-based concentrations, such that no adverse health effects will result from future use of the facility. Presently, more information is available concerning the nature and extent of groundwater contamination than is known about soil, surface water, and sediment contamination within the O-Line Ponds area. Because contaminated groundwater potentially poses an unacceptably high level of risk to human health, this environmental medium has been separated from the others. This separation of environmental media into Operable Units (OU) allows the Army to begin groundwater cleanup prior to full assessment of the entire NPL site.

An Operable Unit (OU) is defined by the National Oil and Hazardous Substances Pollution Contingency Plan (40 CFR 300.5) as a discrete action which is an incremental step towards comprehensively mitigating site problems. The Operable Units for the NPL site at MAAP have been defined as follows:

OU 1: Contaminated groundwater beneath and immediately downgradient from the former ponds which has been contaminated by past disposal practices at the ponds.

OU 2: Contaminated soils beneath and around the former ponds and surface water and sediment in the drainage ditch that flows along the east and north sides of the ponds, which may have become contaminated as a result

of
past disposal practices.

OU 14: Soil and water media in the area downgradient (to the north and northwest) of OU 1 and OU 2, including Line K.

This Interim Action ROD applies to OU 1. OU 2 and OU 14 require additional investigation and will be handled as separate actions. A final action ROD will be prepared to comprehensively address OU 1, OU 2, and OU 14, which make up the NPL site.

OU 1 consists of groundwater that has been contaminated by explosives compounds that seeped from the ponds during past waste disposal operations. The primary contaminants in groundwater are HMX, RDX, 2,4,6-TNT, 1,3,5-TNB, 2,4-DNT, 2,6-DNT, 1,3-DNB, and nitrobenzene.

Because drinking water wells are not located in the area of contaminated groundwater, there is currently no risk posed to facility workers or area residents by the Operable Unit. However, the baseline risk assessment conducted as part of the FFS (USATHAMA, 1992a) indicates that the explosives contamination in groundwater may pose a threat to human health should the area be developed for residential use in the future. Contaminant migration toward the installation boundary is projected to lead to an unacceptable health risk level for off-post residential use of groundwater.

The clean-up objectives for OU 1 are to extract and treat contaminated groundwater to prevent current or future exposure to explosive compounds. The overall strategy consists of the following three steps:

- Contaminated groundwater will be pumped out of the aquifer;

- Extracted groundwater will be treated with a combination of metals and explosives treatment technologies; and

- Treated groundwater will be safely disposed; possible methods include re-injection or discharge to surface water.

In pursuit of the overall goal of reducing the levels of contaminants to health-based levels, UV-oxidation, an innovative technology, will be used to remove explosive compounds from extracted groundwater. Thistechnology was selected because of uncertainties regarding the ability of more commonly-used technologies in reducing the concentrations of contaminants to the health-based levels. UV-oxidation has not previously been applied in full-scale systems to remove these contaminants; however, it has the potential to meet the stringent criteria.

The Army has elected to perform this phase of groundwater cleanup under an Interim Record of Decision (ROD), which allows for treatment system design, construction, operation (using the discharge limits listed in Section 9.0, which for several explosives compounds are higher than health-based concentrations), and performance evaluation for a set period of time. At the end of the performance evaluation period, the treatment system capabilities and discharge levels will be reevaluated. If the health-based levels for the contaminants of concern have changed in the interim, these new values will become the treatment goals. A final remedy will be selected which satisfies all health based clean-up levels or provides technical data, consistent with CERCLA and the National Contingency Plan, which justifies alternative standards.

The interim remedial action will greatly reduce the potential human health risks associated with the hypothetical ingestion, dermal contact, or inhalation of contaminants in groundwater. Treatment of the groundwater will destroy and remove explosives, thereby reducing the toxicity and volume of contaminants in groundwater. In addition, groundwater extraction will serve to eliminate the migration of contaminated groundwater to off-site areas.

Because this interim remedial action requires that the further migration of contaminated groundwater within the O-Line Ponds area be stopped, and the concentrations of contaminants in groundwater be greatly reduced, it is consistent with any planned future actions.

5.0 SITE CHARACTERISTICS

This section provides an overview of the O-Line Ponds characteristics related to OU 1 including a summary of the hydrogeologic setting, the nature and extent of groundwater contamination, potential routes of contaminant migration and exposure, and a summary of human health and ecological risks. The information presented in this section was summarized from the RI (USATHAMA, 1991) and FFS (USATHAMA, 1992a).

5.1 HYDROGEOLOGIC SETTING

Sands in the Claiborne and Wilcox Group are the principal sources of groundwater in western Tennessee. The major aquifer at MAAP occurs within the Memphis Sand of the Claiborne Group, which are deposits of Tertiary age in the Gulf Coastal Plain of western Tennessee. The total depth of this unconfined aquifer is on the order of 250 feet in the areas of interest at MAAP, and the major controls on groundwater movement are the dip of the sediments, surface topography, and surface recharge and discharge patterns. Groundwater flow in the MAAP area is generally to the west, in the direction of regional dip of these sands, and also trends northerly because of the topographic influence. The gradient of the sands is estimated to be about 20 feet/mile to the northwest. On a general scale, there are no abrupt hydrologic boundaries in the aquifer. The sandy formation contains local clay lenses and clay rich zones which may locally alter vertical groundwater flow, and stratification of the sediments also tends to make vertical conductivities lower than horizontal conductivities.

Groundwater flows in a direction perpendicular to groundwater contour lines at a rate determined by the hydraulic gradient, i = h L, (i.e., the hydraulic head over a given distance); the specific yield of the aquifer; and the hydraulic conductivity (estimated from aquifer test results to be approximately 27 feet per day). The pathlines shown in Figure 5-1 illustrate the general flow directions for groundwater beneath MAAP. The horizontal hydraulic gradient is very low at MAAP, resulting in a low velocity for groundwater flow. From water level data, the horizontal hydraulic gradient is estimated as 0.0015 ft/ft. For an aquifer specific yield of 20% (a representative value for this aquifer material), the average groundwater flow velocity is calculated to be 0.20 ft/day. Small variations in flow velocity are expected for various areas of the facility, depending on variations in the controlling factors.

In the vicinity of the O-Line Ponds, groundwater is recharged by precipitation infiltration in the higher-elevation southern portion of the facility, and infiltration is enhanced through the floor of the drainage ditches in the area. Partial discharge of groundwater to the Rutherford Fork of the Obion River is indicated by considering the relationships between elevations of the water table, the variation of hydraulic potential with depth, and the elevation of the stream surface.

5.2 CONTAMINATION ASSESSMENT

The results of the RI (USATHAMA, 1991) indicate the principal sources of explosives contamination in groundwater at MAAP are the O-Line Ponds and the drainage ditches from this area. The groundwater in this area of the installation contains organic contaminants (the explosives compounds 2,4,6-TNT, HMX, RDX, nitrobenzene, 2,4-DNT, 2,6-DNT, 1,3,5-TNB, and 1,3-DNB). Of the contaminants found in the near vicinity of the O-Line Ponds, 2,4,6TNT, RDX, and the DNT isomers are present in the highest concentrations and/or pose the greatest risk. 2,4-DNT and 2,6-DNT are Class B2 carcinogens (meaning they are probable human carcinogens based on sufficient data from animal studies and inadequate data from human studies) and RDX and 2,4,6-TNT are designated as Class C carcinogens (they are possible human carcinogens based on inadequate evidence from human studies and limited evidence from animal

studies). Section 6.0 of this Record of Decision provides more detail concerning the baseline risks and potential routes of human and environmental exposure of these contaminants.

5.2.1 Summary of Remedial Investigation Results

The groundwater data collected during the RI show that explosivescontaminated groundwater near the O-Line Ponds is migrating slowly toward the north. Figures 5-2 and 5-3 show the concentrations of RDX and 2,4,6-TNT, respectively, detected in the wells downgradient and cross-gradient of the O-Line Ponds area during the RI field investigation. Concentration plots for the other explosives-related contaminants exhibit this same general configuration, but are smaller in areal extent. High concentrations in the southern portion of the contaminated zone are attributed to inputs from the O-Line Ponds, and the extended areas exhibiting lower concentrations in the northern portion of the contaminated zone are attributed to inputs from the drainage ditches. The action under consideration addresses only the groundwater in the near vicinity of the O-Line Ponds; therefore, only the southern portion of the contaminated zone shown in Figures 5-2 and 5-3 are of interest. (The remaining contamination arising from the drainage ditches will be addressed in a separate action).

The movement of contamination in groundwater from the vicinity of the O-Line Ponds toward the north is explained by advective-dispersive processes. Mechanical dispersion appears to be the dominant process causing lateral spread of contamination.

5.2.2 Summary of Post-RI Sampling and Analysis

In January-February of 1992, additional field work was conducted to further evaluate the nature and extent of contamination at the O-Line Ponds area. Data from chemical analysis of groundwater samples indicate that the levels of explosive compounds in the shallow aquifer near the O-Line Ponds have decreased from the time that the RI sampling occurred; the reason for this is not known. The data further show that the only detectable organic compounds in groundwater immediately downgradient of the capped area are explosives residues, and inorganic constituents (metals) are only of concern in regard to possible interference with organic treatment processes.

5.2.3 Extent of Groundwater Contamination

The chemical data collected during the RI show that shallow groundwater in the zone immediately downgradient of the O-Line Ponds (e.g., from wells MI001 and MI058) had very high levels of explosives. Groundwater from an intermediate depth in the aquifer (e.g., from wells MI057 and MI075) show much lower concentrations of explosives, indicating that the levels of contaminants falls off rapidly with depth. However, explosives were detected above health advisories in well MI075, which is located directly downgradient of the O-Line Ponds, at a depth of 170 feet (the depth to groundwater is approximately 45 feet in this area). Based on the configuration of contaminated zones developed during the RI and the depth at which contamination has been detected, it is estimated that the zone of contaminated groundwater comprising this operable unit has approximate dimensions of 1,500 feet in width, 2,500 feet in length and 125 feet in depth. Using these dimensions and a soil porosity of 20%, it is estimated that approximately 1 X 10[8] gallons of water may be contaminated to an extent such that extraction and treatment should be considered.

6.0 SUMMARY OF SITE RISKS

Risk assessment consists of the evaluation of the types and levels of contaminants present within the Operable Unit, the pathways by which receptors could potentially be exposed to these contaminants, and the toxicity and/or carcinogenicity of the contaminants. A quantitative estimate of the potential for adverse health effects to occur in the future can be constructed from these data. In estimating these risks, the assumption was made that no remedial action would be taken to address contamination within the Operable Unit; the resulting analysis is referred to as a baseline risk assessment. The main focus of this baseline risk assessment is to evaluate potential risks associated with the use of, and exposure to, untreated groundwater immediately adjacent to the O-Line Ponds (OU 1).

As discussed in Section 1.0, there are scattered residences to the north and east of the facility boundary. Downgradient of the O-Line Ponds area, the nearest residences are located north of the Rutherford Fork and at a distance of approximately 1.5 miles from the O-Line Ponds. Homeowners on the east side of the facility are not at risk from the contamination emanating from the O-Line Ponds because they are cross-gradient and upgradient from the OLine Ponds. Within the facility, the Army performs regular monitoring of the potable water production wells to ensure that no contamination is present. Therefore, under current conditions, humans are not exposed to the contaminated groundwater in the O-Line Ponds area.

Although MAAP is a currently operating government facility which is not scheduled for realignment under the Base Closure and Realignment Act, the most stringent possible future land use scenario was used in estimating the risks. This was done to ensure that the potential risks would not be underestimated. The most stringent future land-use conditions consist of residential development of the O-Line Ponds area. Under these conditions, the residents living at the O-Line Ponds would be exposed to contaminated groundwater via ingestion, which is the exposure pathway that poses the greatest threat to human health.

Homeowners in this area of western Tennessee tend not to installdrinking water wells deeper than necessary to obtain sufficient quantities of water. The high permeability of the Memphis Sand aquifer results in adequate well yield even at shallow depths within the aquifer. Therefore, the assumption was made in this baseline risk assessment that on-site residents would be exposed to levels of contaminants immediately downgradient from the O-Line Ponds and shallow within the aquifer. The two monitoring wells corresponding to these conditions are MI001 and MI058.

To evaluate the risk posed by all organic and inorganic constituents within the shallow aquifer, the wells were sampled in January 1992. These data present the most complete and up-to-date picture of conditions immediately downgradient from the O-Line Ponds; therefore, the baseline risk assessment was performed using these analytical data.

6.1 Chemicals Of Potential Concern

Chemicals of potential concern are those chemicals believed to be associated with past activities at the O-Line Ponds. Table 6-1 lists all of the chemical analytes detected in monitoring wells MI001 and MI058 in January 1992. All of the listed analytes were used in estimating the potential risk; however, many of the analytes are not considered chemicals of concern. The chemicals that are not of concern are those inorganic analytes that are essential nutrients or were detected at levels well

below health-based limits, and those organic compounds that are considered sampling or laboratory artifacts. This is further discussed below.

Of the organic compounds selected as chemicals of potential concern, three were detected at the highest concentrations in both monitoring wells MI001 and MI058: HMX (1,200 ug/L and 1,100 ug/l, respectively), RDX (6,400 ug/l and 7,800 ug/l, respectively), and 2,4,6-TNT (6,500 ug/l and 15,500 ug/l,respectively). 1,3,5-TNB was also present in significant quantities in well MI058. The other explosives compounds were detected at levels less than 750 ug/l and are also included in the risk assessment.

The organic compounds carbon disulfide, 2-propanol, and 1,1,2,2-tetrachloroethane were detected at very low levels. 2Propanol was used to decontaminate sampling equipment and is therefore considered an artifact of the sampling activity. 1,1,2,2-Tetrachloroethane is a common solvent and may be a laboratory artifact; the fact that it was detected in only one of the shallow wells makes this more likely. These two chemicals have been retained in the risk assessment, but are not considered chemicals of concern because of the likelihood that they were detected in error. Carbon disulfide was detected in both shallow wells and is therefore considered a chemical of concern; however, as will be discussed in Section 6.4, the concentration at which this contaminant was detected is too low to indicate potential adverse health effects could occur through lifetime ingestion of groundwater.

Of the inorganic chemicals detected in monitoring wells MI001 and MI058, the six essential nutrients (aluminum, calcium, iron, magnesium, potassium and sodium) were detected at the greatest concentrations. Barium and manganese were also detected at significant concentrations in both wells (109 to 237 ug/l and 596 to 1,080 ug/l, respectively). All other inorganic chemicals were detected at levels less than 40.8 ug/l.

6.2 Exposure Assessment

This risk assessment focused solely on potential human health risks associated with ingestion of untreated groundwater from monitoring wells MI001 and MI058. Persons using untreated groundwater as a domestic water supply could be exposed to chemicals in groundwater via ingestion of drinking water. However, under current land-use conditions, untreated groundwater is not used by residents or other individuals; therefore, no complete exposure pathways exist. Under future land-use conditions, potential exposures and risks associated with ingestion of groundwater have been evaluated to provide a risk-based measure of the levels of contamination associated with the suspected source area.

Chronic daily intakes (CDIs) are calculated for residential drinking water exposures using the estimated exposure point concentrations presented in Table 6-2. A reasonable maximum exposure (RME) case was evaluated in accordance with EPA guidance. It was assumed that chemical concentrations in the monitoring wells would remain constant over the duration of the exposure period. CDIs were estimated for groundwater ingestion using the equation and assumptions presented below:

CDI=(Cw*IR*EF*EDZ)/(BW*AT*Days)

where
CDI = chronic daily intake (mg/kg-day),
C_w = chemical concentration in groundwater (mg/l),
IR = water ingestion rate (l/day)
EF = frequency of exposure (days/year),
ED = duration of exposure (years),
BW = average body weight (kg),
AT = averaging time (70 years for carcinogens, 30 years for noncarcinogens), and Days = conversion factor (365 days/year).

Drinking water exposures are evaluated for a resident between the ages of 0 through 30. For persons 0-30 years of age, a time-weighted average body weight of 48 kg (based on data in USEPA 1989d), and a drinking water rate of 1.9 liters/day are used as parameters for the reasonable maximum exposure (RME) case. The drinking water consumption rate has been calculated assuming a consumption rate of 1 liter/day for individuals up to 10 kg (approximately 3 years of age), and a rate of 2 liters/day for persons over 3 years of age. An exposure duration of 30 years, the upper-bound time at one residence, is assumed for residents (USEPA 1991, 1989a).

CDIs for carcinogens and for noncarcinogens in groundwater at the O-Line Ponds are presented in Table 6-2.

6.3 Toxicity Assessment

Quantitative risk assessment involves combining intakes for exposed populations with reference doses (RfDs, defined as acceptable daily doses for noncarcinogens) or slope factors (for carcinogens) to derive estimates of noncarcinogenic hazard, or excess lifetime cancer risks, of the potentially exposed populations. Table 6-2 presents chronic oral health effects criteria (slope factors and RfDs) for the chemicals of potential concern to be quantitatively evaluated in this assessment.

No oral health effects criteria are available for aluminum, calcium, iron, lead, magnesium, potassium, 2-propanol and sodium; therefore, potential risks associated with ingestion of these chemicals will not be quantitatively evaluated. Exclusion of these chemicals from the quantitative evaluation is not expected to result in significant underestimates of risk. The essential nutrients (aluminum, calcium, iron, magnesium, potassium, and sodium) are not likely to pose adverse health effects at the concentrations present in groundwater within the O-Line Ponds area.

6.4 Risk Characterization

For carcinogens, potential risks are calculated as the product of the chronic daily intake (CDI) and slope factors. Risks were compared to EPA's target risk range of 10[-4] to 10[-6]. An excess lifetime cancer risk of 10[6] indicates that an individual's risk of cancer, over a lifetime, is increased by one in a million due to exposure to the carcinogen. For noncarcinogens, potential hazards are presented as the ratio of the CDI to the reference dose (CDI:RfD), and the sum of the ratios is referred to as the hazard index. In general, hazard indices that are less than one are not likely to beassociated with adverse health effects, and are therefore less likely to be of regulatory concern than hazard indices greater than one.

Carcinogenic and noncarcinogenic risks associated with the ingestion of untreated groundwater from monitoring wells MI001 and MI058 by future residents are presented in Table 6-2. The estimated upper bound excess lifetime cancer risks for ingestion of groundwater from MI001 is 1x10[-2]. This risk exceeds EPA's target risk range of 10[-6] to 10[-4] range for human health protectiveness, and is due primarily to RDX and 2,4,6-TNT, although 2,4-DNT and 2,6-DNT also contributed to the elevated risks.

The excess lifetime cancer risk for a future resident ingesting groundwater from MI058 is 2x10[-2] as presented in Table 6-2, and this value also exceeds EPA's risk range for human health protectiveness. The primary chemicals contributing to this risk are RDX, 2,4,6-TNT and 2,4-DNT. It is important to note that RDX and 2,4,6-TNT are Class C carcinogens, and therefore their carcinogenic risks could be overestimated. The carcinogenic risks from such possible human carcinogens are based on inadequate evidence from human studies and limited evidence from animal studies. Therefore, the carcinogenic risk levels are calculated conservatively and could be over estimated. For noncarcinogenic chemicals, the hazard index exceeded one for both MI001 (HI= 1,000) and MI058 (HI= 3,000) due to 1,3-DNB, nitrobenzene, RDX, 1,3,5-TNB[1] and 2,4,6-TNT.

The highest detected concentration of lead was 1.25 ug/l in monitoring well MI001. This concentration is less than the suggested EPA final "clean-up" level of 15 ug/l for lead in groundwater (USEPA 1989b). Groundwater concentrations of 15 ug/l lead are considered protective by EPA (USEPA 1990a) and are likely to correlate with blood lead levels below 10 ug/l in roughly 99 percent of young children who are not exposed to excessive lead paint hazards or heavily contaminated soils. Therefore, the lead in groundwater is notlikely to contribute to the overall risk to future residents.

6.5 FUTURE OFF-SITE HUMAN HEALTH RISKS

There are no current pathways whereby human health could be adversely affected from exposure to the groundwater near the O-Line Ponds. Therefore, the RI focused on evaluating the potential future risks associated with eventual migration of contaminated groundwater from the O-Line Ponds area to off-post areas where exposures via residential use could occur. This future -exposure scenario was evaluated using a groundwater model based on advective-dispersive flow to determine future concentrations in the event that no control on migration or removal of contaminants is implemented. The model predicted that many decades would be required before contamination from the O-Line Ponds area would reach the facility boundary, but unacceptably high risks ultimately may be present if migration is allowed to continue unabated. The results showed that the combined lifetime cancer risks from potential exposure to groundwater at the facility boundary would exceed the 10^{-5} risk level, and the hazard indices for noncarcinogenic health effects also would be excessive.

6.6 ECOLOGICAL IMPACTS

The RI did not identify any unacceptable on-site ecological risks due to contaminated groundwater. An evaluation of the ecological risks associated with contaminated soil, surface water, and sediment in the vicinity of the O -Line Ponds area is being performed as part of the FFS for OU 2. In addition, any off-site ecological impacts will be addressed in the Ecological Risk Assessment for the entire Milan Army Ammunition Plant, targeted for publication in 1994.

<Footnote>
1 The U.S. Army Biological Research and Development Laboratory is currently conducting sub-chronic animal studies of the toxicity of this compound.
</footnote>

6.7 BASELINE RISK ASSESSMENT SUMMARY

The following conclusions may be drawn from the baseline risk assessment:

- Groundwater contamination associated with past use of the O-Line Ponds does not pose any short-term risk to human health or the environment under current land use conditions because groundwater in this area is not used as drinking water;

- Human health impacts are possible, however, if the O-Line Ponds area is developed for residential use and groundwater is used as a source of drinking water;

- Carcinogenic risk under the future residential land use scenario is due principally to the presence of high levels of explosive compounds in shallow groundwater immediately downgradient of the OLine Ponds;

- Adverse health effects posed by noncarcinogens under the future residential land use scenario are also due principally to explosive compounds;

- The quantitation of risk indicates that the inorganic analytes are not at levels high enough to cause adverse health effects.

The baseline risk assessment indicates that groundwater quality in the O-Line Ponds area has been impacted and that use of this groundwater, currently or into the foreseeable future, for drinking water would result in significant human health risks. The removal of explosive compounds from groundwater will reduce the overall carcinogenic and noncarcinogenic risks to acceptable levels.

This interim remedial action will stop the further migration of contaminated groundwater in the immediate vicinity of the O-Line Ponds area through extraction of groundwater from the aquifer. Groundwater extraction and treatment will greatly reduce the concentrations of the chemicalsof concern. Therefore, implementation of this interim remedial action will result in significant reduction of the risks potentially posed by the Operable Unit. The goal of the final remedy for the site is to reduce the concentrations of contaminants in groundwater to below health-based levels. The final action remedy will ensure that treatment of groundwater will occur to the maximum extent practicable, consistent with CERCLA and the National Contingency Plan.

Actual or threatened releases of hazardous substances from this site if not addressed by implementing the response action selected in this ROD, may present a current or potential threat to public health, welfare or the environment.

7.0 DESCRIPTION OF ALTERNATIVES

Groundwater remedial alternatives were developed for OU 1 to satisfy the following remediation objectives:

- Protect human health and the environment;

- Reduce the levels of contaminants to concentrations such that off-site future groundwater users will not be exposed to the contaminants above health-based levels;

- Use permanent solutions and treatment technologies; and

- Achieve a remedy in a cost-effective manner.

This section describes the extraction system and the treatment and discharge alternatives for groundwater.

7.1 ALTERNATIVE T-1: NO ACTION

The NCP requires that the "no action" alternative be evaluated at every site to establish a baseline for comparison. Under this alternative, no remedial action would occur to prevent current or future exposure to the groundwater contamination. Alternative T-1 does not have associated capital and operation and maintenance costs, and will not require any time forimplementation.

7.2 ALTERNATIVE T-2: LIMITED ACTION

Alternative T-2 consists of long-term monitoring, physical barriers, and administrative actions. The "limited action" alternative does not reduce the toxicity, mobility, or volume of contamination but would reduce the probability of physical contact with contaminated media. Institutional controls such as deed, access and land use restrictions would be implemented to reduce physical contact with contaminated groundwater. Public education programs would be designed to inform the workers and local residents of the potential site dangers. In addition, emergency provisions would provide a plan of action in the event of an accidental exposure or sudden increase in risks associated with the Operable Unit. Long-term environmental monitoring will be conducted at the O-Line Ponds area as well as quarterly sampling for target pollutants in groundwater and surface water. The data collected from the monitoring program will be reviewed at a minimum of every five years as required by the NCP at all sites where hazardous chemicals remain untreated.

The purpose of this alternative is to inform the public, provide a data base, and evaluate changes in site conditions over time. Alternative T-2 has an estimated capital cost of $49,000 and annual operation and maintenance costs of $171,000. Present worth is estimated at $2,678,000 for a thirty year period at a five percent discount rate.

7.3 COMMON ELEMENTS IN TREATMENT ALTERNATIVES T-3 THROUGH T-8

The remaining groundwater treatment alternatives contain a number of common features. Except for the "No Action" and "Limited Action" alternatives (Alternatives T-1 and T-2), all of the alternatives now being considered for the Operable Unit include collection technologies, on-site treatment, and discharge. Collection technologies involve the removal of contaminated groundwater from the aquifer through use of extraction wells. The extracted water will be piped to an on-site treatment system through an aboveground piping system. On-site treatment would consist of a combination of chemical and physical treatment technologies. The treatment alternatives vary only in the combination of these chemical and physical processes used to meet required treatment effectiveness and different discharge criteria.

7.3.1 Interim Remedial Action Treatment System Goals

The goal of this interim remedial action is to reduce the human health risks posed by conditions within the Operable Unit. This goal will be pursued by preventing future human exposure to contaminated groundwater through the use of both active groundwater remediation (extraction, treatment, and discharge) and institutional controls.

To lower the potential carcinogenic and noncarcinogenic risks to acceptable levels within the area of interest, the concentrations of explosives compounds must be reduced to extremely low levels (this is further discussed in Section 9.0). At present, it is not known if any currently-available treatment technologies are capable of achieving this level of efficiency on a consistent basis for the required high flow rate and for this combination and concentration of contaminants. The FFS for this Operable Unit identified the most promising technologies and both bench- and pilot-scale treatability studies have been performed to evaluate the effectiveness of these technologies. However, the technologies were tested at relatively small scale and the impact of system scale-up on treatment plant efficiency is not known.

For this reason, the Army has elected to choose the most promising remedial technology and apply it to the Operable Unit under this Interim Action ROD. At a minimum, the treatment system will be operated such that healthbased levels will not be exceeded at the facility boundary; off-site residents will therefore be protected from the contaminants associated with the Operable Unit. At the same time, institutional controls will preclude human exposure to the contaminated groundwater.

The treatment technologies introduced and described in this section were selected not only for their ability to protect off-site users but also for their potential to reduce the on-site concentrations of contaminants to health-based levels. The ARARs and To Be Considered (TBC) standards relevant to this OU are described in Table 10-1 through 10-3. In addition, Federal Ambient Water Quality Criteria and Tennessee Surface Water Standards are ARARs for Alternatives T-4, T-6, and T-8, which include discharges to surface waters.

7.3.2 Extraction System

Each of Alternatives T-3 through T-8 make use of an extraction well system to remove contaminated groundwater from the aquifer immediately downgradient of the O-Line Ponds area. Continuous pumping from the extraction wells will also lower the water table in this area and reverse the hydraulic gradient on the downgradient side. Further migration of the groundwater currently within the contaminated area will therefore be prevented by this system.

Because of the large lateral and vertical extent of contamination within the area to be remediated, multiple extraction wells will be needed. It was assumed in developing the extraction system cost estimate that six 6-inch diameter wells will be installed to depths of 125 feet. Submersible pumps will be used to pump water to ground level. The piping from the wells to the treatment plant will be corrosion-resistant and heated to prevent freezing.

The extraction system has an estimated capital cost of $327,000 and annual operation and maintenance costs of $16,000. Present worth is estimated at $573,000 for a thirty year period at a five percent discount rate. These costs must be added to the cost estimates for each treatment/dischargealternative to arrive at a total system cost.

7.3.3 Discharge Options

The two discharge options under consideration are re-injection into the aquifer and surface water discharge. Alternatives T-3, T-5, and T-7 include re-injection as the discharge method. In these alternatives, a series of injection wells will be installed upgradient of the former ponds. As treated water is re-introduced into the aquifer, the hydraulic gradient between the injection wells and the extraction wells will increase, and this will result in a higher rate of groundwater flow between the sets of wells. It is anticipated that use of the re-injection discharge option (and resulting control over the hydraulic gradient) will increase extraction system efficiency and shorten the amount of time needed to extract the groundwater currently within the contaminated area. Upgradient re-injection offers the additional advantage of creating a closed-loop system. The potential for adverse environmental impacts to occur is reduced because the treatment system effluent will not leave the Operable Unit.

Alternatives T-4, T-6, and T-8 include surface water discharge of the treatment system effluent. Because of the high expected flow rate (possibly as high as 500 gallons per minute), it is expected that this discharge method will consist of piping the treated water to the Rutherford Fork of the Obion River. It is not expected that the on-site drainageways could safely handle both the large treatment plant output and the runoff from precipitation events without significant modification. Discharge to the river offers the additional advantage of providing a mixing zone for the effluent. However, because the treated water will continuously be added to the river, the potential exists for ecological impacts to occur.

7.3.4 Other Assumptions Used in the Cost Estimates

The volume of groundwater which requires remediation is estimated to be as large as 10[8] gallons. The on-site treatment systems have a proposed flow rate of 500 gpm in order to reverse the groundwater gradient. It has been estimated that the systems may have to operate for thirty years or more. Due to the long period of treatment anticipated, extensive administrative oversight will be required to ensure the proper operation and maintenance and overall performance of this alternative. Long-term monitoring of influent and effluent concentrations, residual characteristics, and the effectiveness of the alternative will be required. Five year reviews will also be required as part of the long-term monitoring program. Institutional restrictions, public awareness programs, and emergency provisions similar to Alternative T-2 would be implemented.

Details of the treatment process would be determined in the Remedial Design phase through engineering design and analysis and the competitive bidding process. Implementation of each treatment alternative will require the construction of a treatment building and parking/staging area; building heating and lighting; long-term influent and effluent and groundwater monitoring; and a five-year review of Operable Unit conditions.

7.4 ALTERNATIVE T-3: UV-OXIDATION/RE-INJECTION

Alternative T-3 uses ultraviolet (UV)-oxidation to reduce the concentrations of the organic contaminants in the extracted groundwater. UVoxidation is an emerging technology that uses ozone as an oxidant and UV light to break down organic contaminants such as explosives. The UV light enhances the reactivity of ozone by transforming these molecules into highly reactive hydroxyl radicals. These powerful oxidants react with the contaminants in the water, cleaving the chemical bonds and breaking down the organic contaminants into simpler molecules. When carried to completion, the end products of the oxidation process are carbon dioxide, water, and inorganic oxidation productssuch as nitrates.

In this system, the ozone is generated on-site using air and electricity; after use, it is catalyzed into oxygen and vented from the system. To reduce the risk associated with storage and handling of reagents, chemical oxidants will not be used in this system. No off-gases or treatment residuals requiring disposal are generated by this process. Following treatment in the UV-oxidation chamber, the effluent is discharged by re-injection wells back into the aquifer. Therefore, the potential environmental risks associated with operation of this system are negligible.

This alternative is expected to reduce the levels of organic compounds to levels such that health-based limits will not be exceeded at the facility boundary. However, this alternative does not remove inorganic constituents from the groundwater. The results of the baseline risk assessment indicate that the levels of inorganic analytes currently do not pose a threat to human health; however, fouling of the piping/treatment system may result if the groundwater is not treated to remove these inorganic analytes. This could potentially lead to increased system maintenance costs. In addition, it is possible that the levels of inorganic analytes in extracted groundwater could rise above health-based limits either due to extraction from a more contaminated area or the addition of groundwater extracted from other Operable Units. In this case, the treatment system must be modified to provide for treatment of inorganic analytes.

UV-oxidation has not previously been applied in a full-scale treatment system for these contaminants. To assess the potential performance of this technology, the Army has performed bench-and pilot-scale treatability studies of UV-oxidation using groundwater extracted from a highly contaminated monitoring well immediately downgradient of the O-Line Ponds. The results of these studies indicate that significant reduction of the concentrations of explosives compounds can be achieved.

Alternative T-3 has an estimated capital cost of $4,216,000 and annual operation and maintenance costs of $1,243,000. Present worth is estimated at $23,325,000 for a thirty year period at a five percent discount rate.

7.5 ALTERNATIVE T-4: PRECIPITATION/UV-OXIDATION/ION EXCHANGE/SURFACE WATER DISCHARGE

This alternative incorporates physical and chemical processes to treat the groundwater to levels acceptable for surface water discharge. As in

Alternative T-3, UV-oxidation is used to reduce the concentrations of the organic compounds. No treatment residuals are produced through the use of this process.

To ensure that aquatic life will not be impacted by the treatment plant effluent, a series of metals removal technologies are used. Electrochemical precipitation and ion exchange are two treatment technologies which are capable of removing metals from water. Electrochemical precipitation involves the removal of metallic compounds from solution by adsorption and coprecipitation with a ferric hydroxide floc. These solids are eventually dewatered by compression and disposed after proper characterization. If the levels of inorganic analytes in the water must be further reduced, the ion exchange process may be used. Low levels of metals such as cadmium, iron and zinc, are captured in the resin and less toxic ions such as hydrogen or sodium are released. Once the resin is exhausted, the ion exchange unit must be replaced. In some cases, it is possible to recover the metals from the exhausted resin.

Although electrochemical precipitation is not a widely used technology, it employs a simple process and is readily implementable. Both benchand pilot-scale treatability studies were conducted using groundwater extracted from a highly contaminated monitoring well located immediately downgradient of the O-Line Ponds area. The results of these studies indicate that the technology is capable of reducing the concentrations of inorganic analytes to very low levels.

The reagents needed for the electrochemical precipitation process include sodium hydroxide and hydrochloric acid for pH control, a polymer to aid in settling of precipitated solids, and hydrogen peroxide to increase precipitation efficiency. These reagents must be shipped, stored, and handled properly to minimize risks to workers and the environment. In addition, the process generates a filter cake consisting of iron and the inorganics removed from the groundwater. Although the filter cake is not expected to be a hazardous waste, it must still be handled and disposed as a solid waste.

The ion exchange technology is widely-applied and reliable. Chemical reagents are not needed in this process. However, the exhausted resin must be handled and disposed.

This alternative relies on technologies that require chemical reagents and/or require proper handling and disposal of treatment residuals. These treatment residuals are not expected to constitute a hazardous waste but must be treated as solid waste. In addition, the treatment system effluent is discharged directly to surface water. Therefore, low to moderate environmental risks are posed by this alternative.

Alternative T-4 has an estimated capital cost of $6,030,000 and annual operation and maintenance costs of $2,691,000. Present worth is estimated at $47,397,000 for a thirty year period at a five percent discount rate.

7.6 ALTERNATIVE T-5: PRECIPITATION/GRANULAR ACTIVATED CARBON (GAC)/RE-INJECTION

This alternative incorporates GAC to reduce the levels of explosives such that health-based levels will not be exceeded at the facility boundary. GAC is a widely-applied and well-understood technology for removal of organic compounds from water. This process relies on the physical adsorption of organic molecules onto a porous carbon matrix containing active adsorption sites. The rate of adsorption is compound-specific, and compounds that are less soluble in water are more likely to be adsorbed. The explosives compounds are moderately soluble and therefore have a moderate affinity for carbon.

The facility currently uses GAC to treat all process water; therefore, performance data are available to evaluate this technology for the Operable Unit-specific contaminants. However, the discharge levels set for the facility treatment plants are much higher than the health-based limits for the explosives compounds; therefore, it is not known if GAC is capable of achieving these extremely low levels. In general, the removal efficiency of GAC is reduced at low contaminant concentrations, especially at high flow rates. This is most likely due to channeling within the carbon beds.

Spent carbon loaded with explosives compounds cannot be regenerated (due to the low volatility of the explosives compounds), cannot be efficiently regenerated, and therefore is typically disposed. The spent carbon may constitute a hazardous waste and therefore must be handled in accordance with the requirements of RCRA Subtitle C. Because explosives compounds would be highly concentrated on the spent carbon, and because the weak forces holding the explosives molecules to the carbon are reversible, mismanagement of the carbon may result in further human health risks and/or environmental damage. The carbon usage rate for this alternative is estimated to range from 500 to 1,600 lbs of carbon per day.

Chemical reagents must be handled and stored on site for use in the precipitation system. This alternative utilizes technologies that generate treatment residuals; namely, a large amount of spent carbon and a small amount of filter cake containing iron and other inorganic analytes. There-injection wells used to discharge the treatment system effluent form a closed loop with the extraction wells. Therefore, the environmental risks posed by this technology are expected to be low to moderate.

Under this alternative, the treated water would be discharged through re-injection wells back into the aquifer.

Alternative T-5 has an estimated capital cost of $3,376,000 and annual operation and maintenance costs of $1,964,000. Present worth is estimated at $33,567,000 for a thirty year period at a five percent discount rate.

7.7 ALTERNATIVE T-6: PRECIPITATION/GRANULAR ACTIVATED CARBON (GAC)/ION EXCHANGE/SURFACE WATER DISCHARGE

This alternative is similar to Alternative T-5 except that it may incorporate additional inorganics treatment in order to satisfy surface water discharge requirements. An ion exchange system may follow the GAC treatment to ensure protection of aquatic life.

The electrochemical precipitation unit requires that chemical reagents be handled and stored on site. Residuals generated through the implementation of this alternative are filter cake from the electrochemical precipitation process, a large amount of spent carbon from the GAC units, and exhausted resin from the ion exchange units. In addition, the treatment system effluent is discharged to surface water. The potential environmental risks posed by this alternative are expected to be low to moderate.

Alternative T-6 has an estimated capital cost of $3,701,000 and annual operation and maintenance costs of $3,163,000. Present worth is estimated at $52,324,000 for a thirty year period at a five percent discount rate.

7.8 ALTERNATIVE T-7: PRECIPITATION/UV-OXIDATION/GAC/RE-INJECTION

This alternative incorporates both organic and inorganics treatment processes to ensure that levels of contaminants at the facility boundary willnot exceed health-based limits. Extracted groundwater is pretreated using the electrochemical precipitation system described in Alternative T-4. Metals treatment is implemented to prevent fouling within the piping or the GAC system which follows. Although the concentrations of metals detected in groundwater are not at high enough levels to pose a threat to human health, the implementation of this technology provides inorganics treatment should the levels of metals in the influent increase. After the precipitation process, UV-oxidation is used to reduce the levels of explosives compounds (see Alternative T-3). GAC (see Alternative T-5) is then used as a secondary treatment step to further reduce the concentrations of organic compounds to levels that provide protection of off-site residents. This second organic treatment step is used to treat any organic compounds which were not completely oxidized in the UV-oxidation system and to increase the cost efficiency of the overall system.

The bulk of the explosives compounds are expected to be destroyed through UV-oxidation. Therefore, GAC will be used at a much lower rate through the implementation of this alternative than rates estimated in Alternatives T-5 and T-6. The carbon usage rate for this system is estimated to be between 70 to 150 lbs per day; this is a reduction of 90% from the carbon usage rate estimated for Alternatives T-5 and T-6.

This alternative requires the handling and storage of chemical reagents. The treatment residuals generated from the implementation of this alternative are filter cake from the electrochemical precipitation process and a relatively small amount of spent carbon from the GAC units. The re-injection wells used to discharge the treatment system effluent form a closed loop with the extraction wells. Therefore, the environmental risks posed by implementation of this alternative are expected to be low.

Alternative T-7 has an estimated capital cost of $5,259,000 andannual operation and maintenance costs of $1,413,000. Present worth is estimated at $26,980,000 for a thirty year period at a five percent discount rate.

7.9 ALTERNATIVE T-8: PRECIPITATION/UV-OXIDATION/GAC/ION EXCHANGE/SURFACE WATER DISCHARGE

This alternative is similar to Alternative T-7 in that it combines UV-oxidation and GAC to reduce the levels of explosives compounds in water.

Treatment through ion exchange may be needed to supplement the electrochemical precipitation treatment of inorganics for discharge to surface water.

Chemical reagents must be handled and stored on site for the electrochemical precipitation unit. The treatment residuals include filter cake from the precipitation system and exhausted resin from the ion exchange system. In addition, the effluent is discharged to surface water. Therefore, the potential environmental risks posed by implementation of this system are low to moderate.

Alternative T-8 has an estimated capital cost of $5,583,000 and annual operation and maintenance costs of $2,611,000. Present worth is estimated at $45,720,000 for a thirty year period at a five percent discount rate.

8.0 SUMMARY OF COMPARATIVE ANALYSIS OF ALTERNATIVES

This section evaluates and compares each of the alternatives described in Section 7.0 with respect to the nine criteria used to assess remedial alternatives as outlined in Section 300.430(e) of the NCP. Each of the nine criteria are briefly described below. All of the alternatives which include active treatment and discharge of groundwater (Alternatives T-3 through T-8) were evaluated to meet the threshold criteria of protection of human health and the environment and compliance with ARARs. However, each alternative meets the primary balancing criteria to different degrees. To aid in identifying and assessing relative strengths and weaknesses of the differentremedial alternatives, this section provides a comparative analysis of alternatives. As previously discussed, the alternatives are as follows:

- Alternative T-1, No Action;
- Alternative T-2, Limited Action;
- Alternative T-3, UV-Oxidation/Re-injection;
- Alternative T-4, Precipitation/UV-Oxidation/Ion Exchange/Surface Water Discharge;
- Alternative T-5, Precipitation/GAC/Re-injection;
- Alternative T-6, Precipitation/GAC/Ion Exchange/Surface Water Discharge;
- Alternative T-7, Precipitation/UV-Oxidation/GAC/Reinjection; and
- Alternative T-8, Precipitation/UV-Oxidation/GAC/Ion Exchange/Surface Water Discharge.

8.1 NINE EVALUATION CRITERIA

Section 300.430(e) of the NCP lists nine criteria by which each remedial alternative must be assessed. The acceptability or performance of each alternative against the criteria is evaluated individually so that relative strengths and weaknesses may be identified.

The detailed criteria are briefly defined as follows:

- Overall Protection of Human Health and Environment is used to denote whether a remedy provides adequate protection against harmful effects and describes how human health or environmental risks are eliminated, reduced, or controlled through treatment, engineering controls, or institutional controls.

- Compliance with ARARs addresses whether a remedy will meet all of the applicable or relevant and appropriate requirements of Federal and State environmental statutes and/or provides a basis for invoking a waiver.

- Long-term Effectiveness and Permanence refers to the magnitude of residual risk and the ability of a remedy to maintain reliable protection of human health and the environment, over time, once clean-up goals have been met.

- Reduction of Toxicity, Mobility, or Volume through Treatment is the anticipated performance of the treatment technologies employed in a remedy.

- Short-term Effectiveness refers to the speed with which the remedy achieves protection, as well as the remedy's potential to create adverse impacts on human health and the environment that may result during the construction and implementation period.

- Implementability is the technical and administrative feasibility of a remedy, including the availability of materials and services needed to implement the chosen solution.

- Cost includes both capital and operation and maintenance costs.

- State Acceptance indicates whether, based on its review of the RI/FS Report and Proposed Plan, the State concurs with, opposed, or has no comment on the preferred alternative.

- Community Acceptance assesses in the Record of Decision following a review of the public comments received on the RI/FS Report and the Proposed Plan.

The NCP (Section 300.430 (f)) states that the first two criteria, protection of human health and the environment and compliance with ARARs, are "threshold criteria" which must be met by the selected remedial action. The next five criteria are "primary balancing criteria", and the trade-offswithin this group must be balanced. The preferred alternative will be that alternative which is protective of human health and the environment, is ARAR-compliant, and provides the best combination of primary balancing attributes. The final two criteria, state and community acceptance are "modifying criteria" which are evaluated following comment on the RI/FS reports and the Proposed Plan.

8.2 PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

The six alternatives which incorporate groundwater treatment and discharge (Alternatives T-3 through T-8) provide protection of human health and the environment. When implemented with an extraction system, the contaminated groundwater can be contained and removed from the ground for treatment thereby eliminating the exposure pathway by which off-site residents may be exposed to contaminants currently within the area defined by this Operable Unit. Although these alternatives may not be capable of reducing the concentrations of contaminants to levels below health-based limits, institutional controls will prevent contact with this groundwater, thereby eliminating the exposure pathway within the facility boundary. Alternatives T-3 through T-8 prevent the future degradation of the condition of the off-site groundwater due to contamination currently within this Operable Unit.

Alternative T-1, No Action, will not meet this criterion because no actions are taken to eliminate, reduce or control exposure pathways. Because this alternative does not meet this threshold criterion of protection of human health and the environment, it will not be considered further in the comparison of alternatives. Alternative T-2, Limited Action, does provide some protection in that it limits access to, and use of, the contaminated groundwater through institutional controls. However, these controls do not permanently reduce access to contaminated groundwater.

8.3 COMPLIANCE WITH ARARS

Treatment alternatives T-3 through T-8 are capable of meeting either groundwater ARARs or surface water ARARs; and with the exceptions described below and in Section 9.0, are capable of meeting health-based limits (including EPA Health Advisories and Drinking Water Equivalency Levels established by RfDs and slope factors). Alternatives T-3, T-5 and T-7 are capable of treating the contaminants present to levels acceptable for re-injection (in compliance with groundwater ARARs). Alternatives T-4, T-6, and T-8 incorporate additional treatment technologies to meet surface water ARARs. However, it cannot be determined without additional performance data if any of the alternatives proposed for this remedial action will remediate the groundwater within the facility boundary to the levels set by the EPA Health Advisories for RDX, 2,4,6-TNT, 1,3-DNB, and by the RfD for 1,3,5-TNB.

The Limited Action alternative, Alternative T-2, does not provide any action to reduce the levels of explosive compounds which are presently above the Health Advisories and other health-based levels. Over long periods of time, levels may decrease due to natural degradation and dilution. In this case, eventual compliance with ARARs may be achieved. However, the length of time before this occurs may be extensive. Because this alternative does not meet this threshold requirement of compliance with ARARs, it will not be considered further in the comparison of alternatives.

8.4 LONG-TERM EFFECTIVENESS AND PERMANENCE

Each of the remaining alternatives provide long-term effectiveness and permanence for this limited scope action. Alternatives using UVoxidation (T-3, T-4, T-7 and T-8) are the most effective in the long-term and the most permanent because, if properly designed and optimized, this process leaves no residual waste. However, if complete oxidation is not achieved, intermediates could be formed which may be toxic. Alternative T-3 uses UV-oxidation as the sole treatment process. This alternative has the potential to be very effective in the long term and very permanent. In addition, UV-oxidation can easily be adjusted to accommodate future fluctuations in groundwater contaminant levels. The processes used in Alternative T-4 generate filter cake and exhausted resin from the additional inorganics treatment (precipitation and ion exchange) implemented. These residuals must be disposed properly.

Residuals generation is more of a concern in the remaining alternatives which utilize GAC. Alternative T-7 and T-8 utilize GAC as a polishing step and, therefore, generate a relatively small amount of spent carbon. This polishing step ensures that intermediates which may be generated by the UVoxidation system are not discharged. Alternatives T-5 and T-6 use GAC alone for the removal of organic compounds and, therefore, generate large quantities of spent carbon. Alternatives T-5 through T-8 also generate residuals associated with the removal of inorganic analytes. All four of these alternatives implement precipitation, which produces a filter cake, and Alternatives T-6 and T-8 implement ion exchange, which generates exhausted resin. These residuals, in addition to the spent carbon, must be disposed.

The effectiveness of Alternatives T-3 and T-7 has been evaluated in treatability tests. Both alternatives are capable of reducing the level of explosives to those suitable for discharge. Although the levels of inorganic analytes in the groundwater tested during the treatability tests were suitable for groundwater discharge and required no treatment, future levels may be higher and inorganics treatment may be necessary. Such treatment is not provided under Alternative T-3.

8.5 REDUCTION OF TOXICITY, MOBILITY OR VOLUME THROUGH TREATMENT

Alternatives T-3 through T-8, when used with an extraction alternative, all provide reduction of toxicity, mobility or volume. Each of these alternatives has the potential to treat contaminants to below the specified ARARs. Those alternatives which produce the smallest amount of residuals reduce the toxicity and volume most permanently. Alternative T-3 produces the smallest amount of residuals. Alternative T-4 produces a minimal amount of residuals which include filter cake from the precipitation unit and exhausted resin from the ion exchange units.

Alternative T-7 generates a relatively small quantity of spent carbon as well as filter cake from the precipitation process. Alternative T-8 generates exhausted ion exchange resin in addition to the residuals generated by Alternative T-7. The largest quantities of residuals are produced by Alternative T-5 and T-6 which use GAC alone for organics treatment. Between these two, Alternative T-6 generates more residuals than T-5 because ion exchange is also utilized.

8.6 SHORT-TERM EFFECTIVENESS

Alternatives T-3 through T-8 would take approximately equal amounts of time and effort to implement. All alternatives require that a treatment plant be built and that a discharge system such as re-injection wells or a surface water discharge system be constructed. No additional risks are incurred in the implementation of one alternative as compared to another.

8.7 IMPLEMENTABILITY

All of the alternatives are relatively easy to implement and readily available. However, some alternatives are easier to implement over the long term due to their relatively low maintenance and replacement requirements. Alternative T-3 may the easiest to implement because this system does not require downtime for the replacement and disposal of spent carbon or ion exchange units; however, untreated inorganics in the water may cause downtime due to system fouling. Alternative T-4 requires frequent replacement of ion exchange units. Alternatives T-5 through T-8 all require replacement and disposalof spent carbon. Alternatives T-5 and T-6 have higher carbon usage rates than T-7 and T-8 and must be changed more frequently. In addition, T-6 and T-8 may require ion exchange unit replacement.

UV-oxidation processes used in Alternatives T-3, T-4, T-5 and T-6 are available through a limited number of vendors. The electrochemical precipitation process used in Alternatives T-4 through T-8 is a proprietary system. GAC used in Alternatives T-5 through T-8, and ion exchange systems used in Alternatives T-4, T-6 and T-8, are offered by a large number of vendors.

8.8 COST

Table 8-1 provides a comparison of the costs of the remaining six alternatives.

In general, those alternatives implementing ion exchange (Alternatives T-4, T-6 and T-8) cost significantly more than their respective alternatives which do not use ion exchange systems and implement re-injection for discharge (Alternatives T-3, T-5, and T-7, respectively). The present worth of these alternatives is approximately $20,000,000 more than systems implementing discharge by re-injection. The additional costs are due to the frequent replacement of ion exchange units.

Of those alternatives developed for discharge to re-injection wells (Alternatives T-3, T-5 and T-7), Alternative T-3 has the lowest present worth value. Costs are low due to the relatively simple treatment scheme which uses only UV-oxidation. The present worth value for Alternative T-7 is only slightly higher than that for Alternative T-3. Because UV-oxidation is used as primary treatment and GAC is used as a polishing step in this alternative, the sizes of the systems are much smaller than units used in Alternatives T-3 or T-5. This alternative also implements precipitation, which provides greater protection of human health and the environment at a fractionally greater cost. Alternative T-5 has the highest present worth value due to the large quantitiesof carbon which must be replaced and disposed.

Alternatives developed for discharge to surface water are given in order of increasing present worth cost as follows: Alternative T-8, Alternative T-4, and Alternative T-6. This order closely follows the rationale given above for Alternative T-7, Alternative T-3 and Alternative T-5, respectively.

However, due to the implementation of precipitation in Alternative T-4 which was not implemented in Alternative T-3, the costs for Alternative T-4 are slightly higher than those for Alternative T-8. Overall, costs for Alternatives T-4, T-6, and T-8 are significantly higher due to the implementation of ion exchange.

8.9 STATE ACCEPTANCE

The State of Tennessee concurs with the selection of Alternative T7.

8.10 COMMUNITY ACCEPTANCE

Comments and responses from the July 16, 1992 Public Meeting have been captured in the meeting transcription, which is included in the Responsiveness Summary (Appendix A). No written comments were received during the comment period.

8.11 SUMMARY OF DETAILED EVALUATION

Based on the above, the following general conclusions may be drawn:

- Treating groundwater to meet re-injection criteria for inorganic analytes (as in Alternatives T-3, T-5 and T-7) is less difficult and less costly than meeting Ambient Water Quality Criteria. In addition, re-injection would result in more efficient extraction of contaminated groundwater due to enhanced gradient control. If upgradient re-injection is used, any residuals would be captured by the extraction system and less monitoring may be needed.

- Use of both UV-oxidation (primary treatment) and GAC (polishing step), as in Alternatives T-7 and T-8, appears to be preferable to using either process alone. The advantages of the two-unit system are that intermediates which may result from incomplete oxidation would be removed by the carbon and less system maintenance would be required. Electrical costs are reduced significantly since the UVoxidation system is not used to reduce the level of organics to discharge levels. GAC usage is minimized since the concentration of organics in the influent is greatly reduced through primary treatment.

- It is conceivable that inorganics treatment may be needed in the future due to expansion of the extraction system. Also, the use of precipitation during the pilot-scale treatability studies appeared to increase the efficiency of the UV-oxidation process. It is therefore desirable to have the ability to treat both organics and inorganics.

Based on the comparative analysis given above, the selected remedy is Alternative T-7.

9.0 SELECTED REMEDY

Based upon consideration of the requirements of CERCLA, the detailed analysis of the alternatives, and public comments, the Army, with the concurrence of EPA and TDEC, has determined that extraction of groundwater with treatment through the implementation of Alternative T-7 (precipitation, UV-oxidation, GAC, and re-injection) is the most appropriate interim remedy for OU 1 at the O-Line Ponds Area at the Milan Army Ammunition Plant in Tennessee. Because of the large size and complexity of the treatment system, its design may take between 12 and 24 months. This time estimate includes the treatment system design and review, and preparation of bid packages. Following the design phase the system construction will begin. This includes selection of contractors and equipment suppliers, installation, and start up. Although this section presents details of the selected remedy, some changes may be made based on the remedial design and construction processes.

9.1 EXTRACTION SYSTEM

The mobility of the contaminants in the aquifer will be reduced by reversing and controlling the groundwater gradient through the implementation of a groundwater extraction system. The specific design of this system is dependent on modeling and aquifer testing results. Factors affecting the design of the extraction system are the depth and thickness of the aquifer, the conductivity of the aquifer, and the location of the contaminant plume. The highly conductive aquifer extends from the water table to a depth of approximately 260 feet below ground surface. Explosives compounds have been detected at Health Advisory levels at a depth of 170 feet below ground surface. In the plane parallel to the groundwater flow direction, the contaminant plume is approximately 2,500 feet long. Perpendicular to the flow direction, the apparent width is 1,500 ft. Using these dimensions, a depth to the water table of 45 feet, and a porosity of 20%, the volume of water to be extracted is 1 x 10[8] gallons. Because even very high extraction rates may produce only a relatively small cone of depression in high-permeability aquifers, multiple wells will be needed to reverse the groundwater potential gradient over this large area. It is estimated that groundwater will be extracted from each extraction well at a rate of 50 to 100 gpm. For purposes of arriving at an order-ofmagnitude cost for the extraction system, a representative extraction well system design is presented and evaluated.

This remedy will utilize approximately six extraction wells to achieve groundwater gradient reversal and to extract contaminated groundwater. Large-diameter wells will be constructed of PVC. Submersible pumps will pump water up to ground level where additional pumps will move water to the treatment site. The total extraction rate is estimated to be 500 gpm. The extraction system will be constructed of galvanized steel piping to provide corrosion resistance, and to prevent freezing, pipes will be heated with steam injectors. The potential location of the extraction system is shown along with the proposed re-injection system locations in Figure 9-1.

9.2 TREATMENT AND DISCHARGE SYSTEM: ALTERNATIVE T-7

In this remedy, shown schematically in Figure 9-2, electrochemical precipitation, UV-oxidation and GAC are used in series. The predicted flow rate of the system is 500 gpm based on the extraction rate needed to reverse the groundwater gradient. Groundwater is first pretreated using electrochemical precipitation. The level of inorganics is reduced to levels acceptable for re-injection. UV-oxidation is then used to remove the bulk of the organic compounds from water, and GAC is then used as a polishing step to reduce the levels of explosives compounds to below discharge levels (discussed in more detail below). A granular media filtration unit may be needed between the UV-oxidation and GAC

units to ensure that any solid particles which have formed due to oxidation of metals do not enter the GAC unit. Treated water is then reinjected upgradient of the extraction system to aid in hydraulic gradient control and provide additional flushing of the contaminated groundwater under the OLine Ponds. Each part of the treatment system is described in detail below.

9.2.1 Electrochemical Precipitation

The electrochemical precipitation process is proposed for this Operable Unit because of its relatively low maintenance demands, low residualsproduction, and low chemical reagent usage rate. This process utilizes ferrous ions which coprecipitate heavy metals present in the groundwater. The ions are generated by passing a direct current through a cell containing carbon steel electrodes. Because calcium or ferric salt additives are not used to form a precipitate, the amount of sludge produced is reduced. Precipitates which form settle out in a clarifier, are pumped to a filter press, are dewatered and then disposed in the form of filter cake. The filter cake will be analyzed for hazardous waste characteristics and disposed accordingly.

Treated water is filtered through a granular media filtration system to remove any additional suspended solids prior to treatment with UVoxidation. This procedure should provide adequate pretreatment to eliminate solids which may hinder the UV-oxidation system. When suspended solids begin to appear in the effluent beyond acceptable levels for feed to the UV-oxidation unit, the filter must be backwashed to remove particles which have accumulated on the granular media. These solids will be recirculated through the electrochemical precipitation process.

Electrochemical precipitation will reduce the level of heavy metals and other inorganics to below the groundwater standards. In addition, this process removes inorganics which may cause unnecessary loading on the GAC unit which follows.

9.2.2 UV-Oxidation

The selected remedy incorporates UV-oxidation in combination with GAC for the treatment of groundwater contaminants to levels acceptable for reinjection into the aquifer. The bulk of the explosives contamination in the groundwater will be destroyed through UV-oxidation. The specific treatment goals of the UV-oxidation system is dependent on balancing the economic benefits gained in optimizing operating conditions of the system. After electrochemical precipitation and filtration, groundwater flows through a reactor which contains a series of baffles holding several UV lamps. Ozone, a strong oxidant, is uniformly diffused from the base of the reactor and is transformed into hydroxyl radicals, a reaction that is catalyzed by UV radiation. Having a higher oxidation potential than ozone, these hydroxyl radicals react more readily with the organic molecules. If complete oxidation is achieved, explosive contaminants are oxidized to carbon dioxide, nitrogen, water and salts. Excess ozone is converted to oxygen using a nickel-based catalytic converter prior to being vented to the atmosphere. Small chain aliphatic compounds may be formed as intermediates if complete oxidation is not achieved, so the pH may require adjustment after treatment by UVoxidation. Results from treatability studies have shown that UV-oxidation is highly effective in reducing explosive concentrations in groundwater.

9.2.3 Granular Activated Carbon

The GAC unit proposed for a 500 gpm system consists of 2 to 3 carbon units connected in series. Each unit is capable of holding approximately 20,000 lbs of granular activated carbon (GAC). Because UV-oxidation will remove most organic contaminants, and precipitation will remove inorganics, GAC will be used at a much lower rate than the rates estimated for alternatives that rely solely on GAC for removal of explosives from groundwater. However, if complete oxidation is not achieved with the UV-oxidation process, organic intermediates will also be adsorbed by the carbon and this usage rate may increase.

Exhausted GAC may be disposed through companies such as Solvent Recovery Corporation, which presently accepts the GAC used at the PWTFs at MAAP. Because the carbon is used as fuel, acceptance of the GAC and the costs for disposal are based on the BTU content of the carbon. The exhausted carbon is disposed through a high temperature incineration process operated by thiscompany.

9.2.4 Re-injection

Treated water will be re-injected into the aquifer upgradient of the ponds as shown in Figure 9-1. The location and design of the re-injection well field are dependent on aquifer tests and modeling results. Re-injection wells made of PVC will be screened along the entire depth of the aquifer (approximately 200 feet in length) to ensure adequate injection into the aquifer. Galvanized steel pipes will carry water from the treatment site to the re-injection system.

9.3 PERFORMANCE MONITORING

A monitoring program shall be developed and implemented during the interim response action to ensure that hydraulic control of the groundwater within OU I is maintained. Specifically, an inward and upward gradient within the aquifer must exist to prevent further migration of the contaminated groundwater from the Operable Unit. Information necessary for this determination includes:

- horizontal and vertical gradients in the groundwater within OUI;
- horizontal and vertical contaminant concentration gradients within OUI;
- changes in contaminant concentration or distribution over time; and
- effects of any modifications to the original interim response action.

To provide this information, the groundwater containment performance monitoring plan shall include, at a minimum, the following: locations of new or existing monitoring wells for water quality sampling; frequency of water quality sampling; analytical parameters (focusing on chemicals of concern) and analytical methods to be employed; field sampling methods; specification of water level monitoring locations, methods, and frequencies usingnew or existing wells; and methods for capture zone analysis.

9.3.1 Effluent Monitoring Program

A monitoring plan for the effluent from the treatment plant shall be developed and implemented during the interim response action to ensure that control of the effluent is maintained prior to re-injection. A monitoring program shall be developed during the design phase that provides periodic and/or continuous information on the chemical constituency of the treatment plant effluent.

To provide this information, the effluent monitoring program shall include, at a minimum, the following: analysis of 24-hour composite samples at a frequency of twice a month for total suspended solids, Target Analyte List metals, nitrates, nitrites, volatile organic compounds, and explosives compounds (treatment plant influent concentrations will also be monitored at this frequency and for the above-listed parameters); and continuous monitoring of pH and control within the limits of 5 and 7.

9.4 TREATMENT SYSTEM PERFORMANCE EVALUATION

During the system start-up period, optimization studies shall be performed for reagent addition rates, initial pH for the UV-oxidation step, and pH adjustment method. These data will be used to establish cost-effective operating conditions and will also be used to complete a sensitivity analysis.

The interim remedy will be operated continuously for one year; during this time period, system performance data will be collected and analyzed. In particular, the following information will be recorded for evaluation:

- flow rate and influent concentrations;
- variations in reagent addition rates and any corresponding changes in effluent characteristics;
- electricity usage; and
- frequency of downtime for system maintenance or repair, and the nature of the repairs.

At the end of the one-year evaluation period, and after the toxicity studies of 1,3,5-TNB have been completed and the data analyzed, the Army will prepare the final remedy ROD for OU 1, OU 2, and OU 14. The system performance data will be summarized in this document. The final remedy ROD will also contain the most up-to-date health-based criteria for the chemicals of concern. System performance will be evaluated with respect to any changes in these levels from the health-based level listed herein.

If the Army, EPA, and the State of Tennessee agree that a treatment system cannot reasonably be expected to meet the health-based levels for the chemicals of concern on a consistent basis, then that fact will be documented in the final remedy ROD. Achievable discharge levels will be determined from the system performance data and other relevant information and will be entered into the final remedy ROD.

9.5 INSTITUTIONAL CONTROLS

The Army will ensure protection of on-site future users of groundwater. The active remediation will be supplemented with institutional controls to prevent ingestion of contaminated groundwater associated with OU I. These institutional controls will consist of the following:

- The groundwater within OU I will not be used for potable purposes while the levels of contaminants are higher than healthbased levels; this will be ensured by Milan Army Ammunition Plant Environmental Office review of all projects and leases involving well installation and usage at the facility. Any well installed within the facility will be tested prior to use.

- In accordance with Army Regulation 200-1, entitled Environmental Protection and Enhancement, the Army is required to perform preliminary assessment screening for the subject parcel being excessed. This screening will evaluate potential use of the property, identify any additional remedial activities, and/or place restrictions on the property to protect the future landowners through a document entitled Statement of Condition. The Army will implement the recommendations in the Statement of Condition prior to property transfer.

In addition, a continuing program of public awareness will be used to inform the public of the hazards associated with contaminants that remain within the Operable Unit.

9.6 REMEDIATION GOALS

The goal of this interim action is to reduce the potential human health risks and restore the aquifer to the extent practicable with the proposed technology. Active contaminant concentration reduction in conjunction with natural attenuation in the aquifer will be used to assure that contaminants from this Operable Unit do not affect future off-post drinking water. In addition, institutional controls will be used to prevent on-site future usage of contaminated groundwater and to maintain public awareness of the conditions at the Operable Unit.

The contaminants of concern for this interim remedial action are identified in the baseline risk assessment conducted for this Operable Unit (Section 6.0). The list of chemicals of concern is comprised of all organic contaminants detected in the groundwater samples except those which are probable sampling or laboratory artifacts. In addition, all inorganic analytes detected in the groundwater samples are included except those which are essential nutrients or which were detected at concentrations low enough that no adverse health effects are predicted. Because nitrates are an oxidation product of the explosives breakdown, this analyte is included with the chemicals of concern. The list of chemicals of concern is provided in Table 9-1.

In developing contaminant discharge levels for the proposed remedial action, the following two principal criteria have been applied:

- the discharge levels must be protective of off-post human health; and

- the discharge levels must be technically achievable by a full-scale system.

9.6.1 Federal MCLs and Tennessee Groundwater Standards

For those contaminants for which Federal Maximum Contaminant Levels (MCLs) and/or Tennessee Groundwater Quality Standards are available, discharge levels equal to the chemical-specific ARARs are technically achievable and provide adequate protection of human health and the environment. The discharge levels are listed in Table 9-1.

9.6.2 Health Advisories

For RDX, 2,4,6-TNT, HMX, and 1,3-DNB, EPA has developed Health Advisory levels using the assumption that 80% of human exposure to the contaminants occurs through pathways other than ingestion of groundwater (such as ingestion of crops irrigated with groundwater, showering and bathing, and inhalation). These Health Advisories are not TBC standards for this interim remedial action because the remedy will ensure protection of human health and the environment through active groundwater remediation and institutional controls.

The baseline risk assessment conducted for the groundwater operable unit indicates that under the residential future land use scenario (the most stringent future land use conditions), all significant potential human health risk is due to ingestion of groundwater as drinking water. Otherrisk pathways are far more secondary because of the nature of the contaminants, which are not volatile and do not pose significant risk via the dermal contact exposure route. Also, crop irrigation is not widely practiced in this region.

For the reasons given above, the concentrations corresponding to 100% exposure through drinking water have been selected as the discharge levels. For RDX, 2,4,6-TNT, HMX, and 1,3-DNB, these levels are 10; 10; 2,000; and 5 ug/l, respectively. As will be discussed in the next section, it has been estimated that the concentrations of these contaminants will not exceed the Health Advisory levels (2; 2, 400; and 1 ug/l, respectively) at the facility boundary.

9.6.3 Other Risk-Based Guidance

EPA has classified 2,4- and 2,6-DNT as Group B2 carcinogens and has issued a Slope Factor (SF) of 0.68 (mg/kg/day)[-1] for both isomers. Based on the assumptions of a 70 kg human ingesting 2 L of water per day for a lifetime, a concentration in groundwater of 0.5 ug/l corresponds to an excess cancer risk of 1 x 10[-5]. These slope factors are TBC standards.

For carbon disulfide, nitrobenzene, and 1,3,5-TNB, EPA has issued reference doses (RfD) of 1 x 10[-1], 5 x 10[-4], and 5 x 10[-5] mg/kg-day, respectively. For carbon disulfide and nitrobenzene, these values have been used to calculate concentrations in water which are unlikely to result in adverse health effects. These values are listed in Table 9-1 as 3,500 and 350 ug/l, respectively. For carbon disulfide and nitrobenzene, these RfDs are TBC standards. For 1,3,5-TNB, the RfD is not a TBC standard for this interim remedial action because the remedy will ensure protection of human health and the environment through active groundwater remediation and institutional controls.

It has been concluded from the treatability study data that the rate-limiting compound for ultraviolet oxidation, which is the preferred treatment method because of the high efficiency and lack of treatment residuals, is 1,3,5-TNB. The retention time study indicates that 2,4,6-TNT is readily oxidized into 1,3,5-TNB, which then has greater resistance to the free hydroxyl radicals due to a molecular structure which is less susceptible to attack. Although the concentration of 1,3,5-TNB was eventually reduced to less than the detection limit, a relatively long retention time was needed. Therefore, if the system is designed to treat groundwater such that the concentration of 1,3,5TNB is reduced to extremely low levels, the cost efficiency of the system would be greatly reduced.

Given the difficulty in reducing the concentration to extremely low levels, and the fact that institutional controls will preclude the use of undiluted effluent as a potable water supply, a discharge concentration of 20 ug/l is selected for this compound.

9.6.4 Estimate of Off-Site Concentrations of Contaminants after Remediation

The discharge limits developed in the previous sections specify the maximum concentrations of explosives and other contaminants that may be in the treatment system effluent for this interim remedy. The purpose of setting these discharge levels is to provide protection of human health within the capability of the treatment system. To ensure that the discharge levels are sufficiently protective of off-site groundwater users, an estimate was made of the maximum levels of contaminants in groundwater at the facility boundary. In developing these estimates, it is assumed that the only human health exposure pathway is the transport of contaminants to the facility boundary (approximately 9,000 feet from O-Line) and then ingestion of contaminated water by residents living off site.

The assumption was made that the proposed action will successfully stop the further migration of contaminated groundwater from the O-Line Pondsarea and that re-injection of treated water (with concentrations of contaminants at or below the discharge levels) will occur upgradient of the ponds. The re-injected water will mix with both untreated contaminated groundwater and uncontaminated groundwater. Therefore, the interim remedial action is complete, and in the absence of a final remedial action which achieves all health-based levels, the area downgradient of the re-injection wells (and approximately as long as the currently existing area of contaminated groundwater) will be nearly uniformly contaminated with explosives at levels assumed to be equal to the cleanup levels. Transport of these contaminants will then occur toward the hypothetical receptors on the facility boundary. This is a highly idealized approximate model of contaminant transport, but existing data are not sufficient to formulate a more detailed approach.

The distance from the southernmost edge of the current area of contaminated groundwater to the facility boundary is 9,000 feet. The levels of RDX in groundwater were used in estimating the current length of the area of contaminated groundwater because available data indicate that this is the most areally extensive contaminant. The length of the area within which the concentration exceeds the discharge level is approximately 1,800 feet. Therefore, the off-site levels are estimated to be 5 times smaller than the discharge levels. Using this estimated relationship between discharge levels and off-site levels, the EPA Health Advisory levels for RDX, 2,4,6TNT, 1,3-DNB, and HMX will be met at the facility boundary. The discharge levels therefore provide adequate protection of human health in off-site areas.

9.6.5 Achievement of Remediation Goals

Results from pilot-scale studies performed on groundwater from the O-Line ponds indicate that groundwater may be treated to levels below thedischarge levels established for the groundwater for this Operable Unit. Therefore, treatment of the O-Line Ponds groundwater through the implementation of the selected remedy will reduce the risks posed by the present groundwater to the target risk range specified for this Operable Unit.

9.7 COST OF THE SELECTED REMEDY

A summary of the costs for this alternative are given in Tables 9-2 (extraction system) and 9-3 (treatment and re-injection system). The total capital costs for the treatment system is $2,098,000. Additional capital costs include $206,000 site preparation, $451,000 for the installation of a reinjection system, and $327,000 for the extraction well system. The total present worth of this remedy is estimated to be approximately $27,553,000 (30 years, 5% discount rate), including capital costs of $5,586,000 and annual O&M expenditures of $1,429,000. These costs are preliminary and are subject to change depending on final system design. Cost estimates are based on vendor information and generic unit costs.

The capital costs for the electrochemical precipitation unit will be affected by the selected flow rate. Although the size of the unit will affect the capital cost of the unit, cost versus flow rate is not a linear function due to economies of scale. For the electrochemical precipitation process, flow rate is expected to have a greater effect on equipment size than inlet contaminant concentrations because the size of the equipment is mainly determined by the rate of flocculent settling rather than by a chemical reaction rate. In general, polymers can be added to the groundwater to enhance settling as necessary to respond to contaminant concentration variations. However, the sizing of ancillary equipment such as the filter press is highly dependent upon the contaminant loading in the groundwater and the groundwater flow rate.

The most significant operating costs for electrochemical precipitation are electrical and iron consumption. Electrical consumption and iron dosage are more linearly related to flow rate than to inlet contaminant concentrations. The optimum dosage of iron must be determined through performance testing should the inlet contaminant concentrations change significantly. Filter cake disposal is also a significant operating cost; sludge volume is directly related to the contaminant loading in the groundwater and the groundwater flow rate.

The capital cost for the UV-oxidation unit will be affected by the selected flow rate, the inlet contaminant concentrations, and the effluent concentration desired. Although the size of the unit will affect the capital cost of the unit, cost versus flow rate is not a linear function due to economies of scale. The contaminant concentrations affect the required residence time, which in turn affects the size of the equipment.

The operating costs of the UV-oxidation unit are affected by the flow rate, the inlet contaminant concentrations, and the effluent concentration desired for this first organics treatment step. The two most significant operating costs are electricity and oxidant consumption. Oxidant dosage is proportional to flow rate of the system. Electrical consumption is directly related to the residence time of the groundwater in the unit and the groundwater flow rate (i.e., the size of the unit). The effects of contaminant concentrations on required residence time in the reactor can be estimated using reaction kinetics data obtained during treatability testing. Residence time of the final treatment unit may be adjusted by varying the number of operating UV lamps.

GAC units are designed to provide an adequate contact time given amaximum flow rate. If the flow rate is lower than assumed and the contaminant concentrations are constant, a smaller unit can be specified. The depth of the carbon bed (i.e., the contact time) will not be reduced; however, the crosssectional area of the unit would be reduced. If the flow rate is higher than that assumed and the contaminant concentrations are held constant, a larger unit (i.e., larger cross-sectional area to accommodate the higher flow rate) or a number of small adsorption units in parallel can be designed. In this case, the depth of the carbon bed(s) will be held constant. As with the other treatment units, the cost of the GAC unit will vary with flow rate; however, cost versus flow rate is not a linear function due to economies of scale. The carbon usage rate is also dependent upon the flow rate. If the flow rate is lower than that assumed and the inlet contaminant concentrations are held constant, the carbon usage rate will be lower because the unit is smaller (i.e., holds less carbon) even though the carbon bed life (i.e., time to contaminant breakthrough) does not change. If the flow rate is higher than that assumed and the inlet contaminant concentrations are held constant, the carbon usage rate will be higher because the unit is larger (i.e., holds more carbon) even though the carbon bed life does not change.

The only effect that a change in inlet contaminant concentrations will have on the carbon adsorption unit is on operating costs (i.e., purchase of activated carbon and regeneration/disposal of spent carbon). That is, if the inlet concentrations are lower than assumed (due to extended treatment through UV-oxidation or a decrease in contaminant levels in the groundwater over time), the carbon adsorption bed will have a longer life (i.e., greater time to contaminant breakthrough) and will have to be changed out less frequently; if the inlet contaminant concentrations are higher than assumed, the carbon adsorption bed will have a shorter life and will have to be changedout more frequently.

Re-injection costs are dependent on flow rate only. If the effluent flow from the treatment system is increased, a greater number of re-injection wells will be needed, increasing capital and operating costs. Likewise, if the effluent flow is decreased, fewer wells will be needed to re-inject the water into the aquifer and capital and operating costs will decrease.

10.0 STATUTORY DETERMINATIONS

Executive Order 12580 delegates the authority for carrying out the requirements of CERCLA sections 104(a), (b), and (c)(4) and 121 to the Department of Defense, to be exercised consistent with section 120 of the Act. Therefore, under its legal authorities, the Army's primary responsibility at MAAP is to undertake a remedial action that achieves adequate protection of human health and the environment. In addition, section 121 of CERCLA establishes several other statutory requirements and preferences. These specify that when complete, the final remedial action for the O-Line Ponds area must comply with applicable or relevant and appropriate environmental standards established under Federal and State environmental laws unless a statutory waiver is justified. The final remedy also must be cost-effective and utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable. Finally, the statute includes a preference for remedies that employ treatment that permanently and significantly reduce the volume, toxicity, or mobility of hazardous substances as their principal element. The following sections discuss how the selected interim remedy is consistent with these statutory requirements as far as practicable given the limited scope of the action.

10.1 PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

The selected remedy will contain and remove contaminatedgroundwater from the ground, thereby reducing the risk posed by this potential exposure pathway. This alternative extracts contaminated groundwater, treats it to remove contaminants below the discharge levels listed in Section 9.6 of this ROD, and re-injects the treated water into the aquifer. Groundwater quality will be improved by implementation of the selected remedy and potential health risks will be significantly reduced. No unacceptable short-term risks or cross-media impacts will be caused by implementation of the remedy.

Although contamination will remain within the Operable Unit above health-based levels, institutional controls will prevent contact with these contaminants until a final groundwater remedy is implemented.

10.2 COMPLIANCE WITH APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

The ARARs for this Operable Unit include action-specific, chemicalspecific and location-specific requirements. To-be-considered (TBC) guidance are also listed.

10.2.1 Action-Specific ARARs

This remedy will be operated in accordance with all Federal and Tennessee treatment facility requirements. A list of action-specific ARARs and TBC guidance is presented in Table 10-1.

According to Rule 1200-4-6-.14 of the State of Tennessee Water Laws, re-injection of treated groundwater is permissible. A Class V injection well may be used provided that no hazard to existing or future use of the groundwater as cited in rule 1200-4-6-.05 exists. Groundwater usage under this later rule includes domestic water supply, industrial water supply, livestock watering and wildlife, surface water drainage, and irrigation. The rule stipulates that groundwater used for these purposes may be subject to treatment prior to the actual use. Treatment of extracted groundwater will take place prior to use of a Class V injection well for re-injection, and therefore will not disqualify the groundwater from being used for any of the stated uses in the rule.

Since land re-surfacing and construction activities will be performed upon implementation of a treatment alternative, air quality ARARs are applicable. For each technology within this remedy, applicable air quality regulations will be met. UV-oxidation requires the generation of ozone, a regulated substance, for use as an oxidant. The Tennessee Ambient Air Quality Primary Standard for ozone is 0.12 mg/L by volume (Rule 1200-3-3-.03).

In regards to disposal of the spent carbon and precipitation filter cake, important potential ARARs are the Land Disposal Restrictions (LDRs) implemented by EPA under the Hazardous and Solid Waste Amendments (HSWA). Under these restrictions, hazardous waste may not be landfilled without meeting the prescribed treatment standard. If these restrictions are applicable (i.e., if the spent carbon and/or filter cake are determined to constitute a hazardous waste), then the disposal of the wastes will be performed in compliance with the LDRs.

10.2.2 Chemical-Specific ARARs

The selected interim remedy provides a means of reducing the levels of contamination in extracted groundwater to below clean up levels set by ARARs and TBCs at the facility boundary and will achieve these levels within the facility for most contaminants. The remedy will significantly reduce the concentrations of RDX, 2,4,6-TNT, HMX, and 1,3-DNB within the Operable Unit; however, the health-based limits applicable to these constituents may not be achieved within the facility boundary during this interim action. Further remediation of groundwater within the Operable Unit may be addressed in the subsequent final remedial action. To ensure protection of human health and the environment while the subsequent action is being developed, institutional controls will be used to prevent use of the water.

More stringent Maximum Contaminant Level Goals (MCLGs), established by the Safe Drinking Water Act, are not relevant and appropriate standards given the risks posed by the Operable Unit.

All groundwater ARARs will be achieved through the implementation of the selected remedy. Applicable groundwater ARARs and TBC guidance are listed in Table 10-2.

10.2.3 Location-Specific ARARs

The construction and operation of the treatment facility and extraction/re-injection wells incorporated in this remedy will comply with all location-specific ARARs. A list of location-specific ARARs and TBC guidance is presented in Table 10-3.

10.3 COST EFFECTIVENESS

By implementing both UV-oxidation and GAC for the treatment of explosives in groundwater, the selected remedy represents the best cost/benefit ratio, being only incrementally more costly than the lowest cost option while providing greater protection to human health and the environment.

10.4 UTILIZATION OF PERMANENT SOLUTIONS AND ALTERNATIVE TREATMENT TECHNOLOGIES (OR RESOURCE RECOVERY TECHNOLOGIES) TO THE MAXIMUM EXTENT PRACTICABLE

The selected remedy is not designed or expected to be the final treatment for groundwater at the site; however, the remedy represents the best balance of trade-offs among alternatives, given the limited scope of the action. The selected remedy permanently removes contaminants from the

extracted groundwater and returns the treated water back to the aquifer. UV-Oxidation through the use of ozone and ultraviolet light is capable of breaking down contaminants without generating residuals. This technology is considered an innovative technology and was evaluated in the EPA's Superfund Innovative Technology Evaluation Program (SITE) in 1990 (USEPA, 1990b). A relatively small amount of GAC will be used as a polishing step in this remedy. Although partially addressed in the selected remedy, the statutory preference for remedies that employ treatment that reduces toxicity, mobility, or volume as a principal element will be addressed by the final response action for groundwater.

The remedy was selected with consideration given to the five primary balancing criteria. This remedy is the most effective alternative because it removes both inorganic and organic contaminants from the groundwater. This remedy also reduces the toxicity, mobility or volume of the groundwater through active extraction and treatment. Although other alternatives generated less residuals by not implementing the use of GAC, this alternative was chosen because the additional organics treatment step ensures complete treatment of the groundwater. Short-term effectiveness does not play a large role in the selection of a remedy because all alternatives require the construction of an extraction system and a treatment plant. The selected remedy, however, is slightly more effective in the short-term because this remedy does not generate a large quantity of residuals to be handled and disposed. Although the selected remedy is not the easiest alternative to implement of all the alternatives considered, due to the implementation of three different treatment technologies, the added effectiveness outweighs the added difficulty in implementing this option. The selected remedy costs only slightly more than the least costly alternative yet provides greater protection to human health and the environment. Of the five primary balancing criteria discussed above, long-term effectiveness and permanence and cost were the most decisive factors. The selected remedy provides the most economical means of attaining the highest degree of treatment effectiveness. EPA, the State of Tennessee, and the community accept this alternative.

10.5 PREFERENCE FOR TREATMENT AS A PRINCIPAL ELEMENT

The selected remedy satisfies the statutory preference to utilize permanent solutions and treatment technologies to the maximum extent practicable. An innovative technology, UV-oxidation, will be used to remove the organic contaminants from groundwater such that the treatment system effluent will not contain contaminants above the discharge levels presented in Section 9.6. During the first year of operation, a performance evaluation will be conducted to determine if the treatment plant is capable of meeting the health-based levels on a consistent basis.

Contaminants in the groundwater which have been detected well above health-based guidance levels pose a potential threat to future residents of the area. By extracting the contaminated groundwater, treating it through the use of electrochemical precipitation, UV-oxidation and GAC to levels below remediation goals, and re-injecting it back into the aquifer, this remedy offers the best approach to protecting off-site groundwater conditions and reducing the risks posed by on-site conditions.

This interim remedy only addresses OU 1 and does not address contaminated soil, surface water or sediment present at the O-Line Ponds area. These media are incorporated into OU 2, which will be addressed by the Army.

11.0 DOCUMENTATION OF SIGNIFICANT DIFFERENCES

During EPA and State of Tennessee review of the Proposed Plan, the draft Treatability Study Report, and the draft ROD for OU 1, it was determined that the most appropriate means of expediting the proposed remedy for this Operable Unit is through an Interim Action Record of Decision. This is considered by the Army, EPA, and State of Tennessee to be a significant change. As required by Section 117(b) of CERCLA, the rationale for this significant change is documented in this ROD and in the Administrative Record. This significant change will not result in a change in cost, timing, or level of performance of the remedy.

The decision to address the remedy with an Interim Action ROD was made for the following reasons:

- The treatability study data for the UV-oxidation process indicates that although this technology is highly effective in removing explosives compounds from groundwater, the rate-limiting compound is 1,3,5-trinitrobenzene (1,3,5-TNB).

- The Drinking Water Equivalency Level (DWEL) for 1,3,5TNB, as set by the EPA Reference Dose, is 2 ug/l. The treatability study data indicate that the proposed treatment system may not be able to achieve this level of removal efficiency at full scale, given the expected high flow rate and high influent concentrations. Because 1,3,5-TNB may not be removed to health-based levels, and the performance data necessary to document selection of alternative standards are not yet available, the proposed remedy cannot be considered the final remedy for the site.

. Although the Army is uncertain that the DWEL FOR 1,3,5TNB can be met, the decision was made to move ahead with the action so that contaminated groundwater can be extracted and treated using the proposed system, which represents best available technology. Such an action may be performed under an Interim Action ROD.

The Army is committed to providing a final remedy for the site which satisfies all health-based criteria or provides technical data, consistent with CERCLA and the National Contingency Plan, which justifies alternative standards.

12.0 REFERENCES

Cody et al. 1,3-Dinitrobenzene: Toxic effect in vivo and in vitro. J. Toxicol. Environ. Health 7(5): 829-847, 1981.

Jackson Sun. June 27, 1992.

Milan Mirror Exchange. June 24, 1992.

Registry of Toxic Effects Of Chemical Substances (RTECS), 1983. U.S. Department of Health and Human Services, National Institute for Occupational Safety and Health.

USAEHA, U.S. Army Environmental Hygiene Agency, U.S. Department of the Army. 1978. Potable/Recreational Water Quality Survey No. 31-24-0163-79, Milan Army Ammunition Plant. March 28, 1978.

USATHAMA, U.S. Army Toxic and Hazardous Materials Agency, U.S. Department of the Army. 1978. Installation Assessment of Milan Army Ammunition Plant. Report No. 122. June 1989.

USATHAMA, U.S. Army Toxic and Hazardous Materials Agency, U.S. Department of the Army. 1982a. Milan Army Ammunition Plant Contamination Survey. Report DRXTH-FS-FP-82131. Pugh, D.L.: Envirodyne Engineers. January 1982.

USATHAMA, U.S. Army Toxic and Hazardous Materials Agency, U.S. Department of the Army. 1982b. Milan Army Ammunition Plant O-Line Settling Ponds Closure Plan. Wirth, P.K. September 1982.

USATHAMA, U.S. Army Toxic and Hazardous Materials Agency, U.S. Department of the Army. 1991. Milan Army Ammunition Plant Remedial Investigation Report. Okusu, N., et al.: ICF Technology, Inc., Fairfax, VA. December, 1991.

USATHAMA, U.S. Army Toxic and Hazardous Materials Agency, U.S. Department of the Army. 1992a. Milan Army Ammunition Plant Focused Feasibility Study for Operable Unit One Groundwater Alternatives. McKendry, J., et al.: ICF Technology, Inc., Fairfax, VA. July, 1992.

USATHAMA, U.S. Army Toxic and Hazardous Materials Agency, U.S. Department of the Army. 1992b. Milan Army Ammunition Plant O-Line Ponds Groundwater Operable Unit Proposed Plan. July, 1992.

USEPA, U.S. Environmental Protection Agency. 1988a. Integrated Risk Information System (IRIS). U.S. Environmental Protection Agency, Office of Health and Environmental Assessment. EPA/600/886/032a.

USEPA, U.S. Environmental Protection Agency 1988b. Health Advisory for Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX). Office of Drinking Water. Washington, D.C. November 1988.

USEPA, U.S. Environmental Protection Agency. 1988c. Drinking Water Health Advisory for Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX), U.S. Environmental Protection Agency, Office of Drinking Water. November 1988.